SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JULY 1899.

GENERAL PHYSICS.

977. *Molecular Theory of Friction of Smooth Bodies.* **M. Brillouin.** (Comptes Rendus, 128. pp. 354-355, 1899.)—It is frequently supposed that the phenomena presented by conservative dynamical systems are essentially reversible. By the following simple example, however, the author shows that such is not always the case. Let a freely suspended needle be acted on by a magnet, and let the latter be slowly rotated; if during a complete revolution of the magnet — corresponding to a complete cycle—the needle is not deflected into any positions of unstable equilibrium, then the energy of the system is the same at the end as at the beginning of a cycle. But if the magnet be placed sufficiently close to the needle to give rise to positions of unstable equilibrium, then, *however slowly the magnet be rotated*, the needle on reaching the first unstable position will suddenly swing round, and begin to oscillate about the next position of stability. The kinetic energy of the oscillation will be retained when the cycle has been completed; reversing the cycle will—so far from reducing the needle to rest—increase its kinetic energy. The cycle is thus irreversible. In the immediate neighbourhood of the surface of a body consisting of isolated molecules the forces exerted by which on an external molecule are functions of the distances, the force-function is either strictly or approximately periodic (according as the body is crystalline or amorphous); hence for an external molecule there will be a large number of positions of stability, separated by positions of instability. So that if the body be moved past the external molecule, the kinetic energy of the latter will be increased by the same amount every time the body advances through a molecular distance. It is therefore evident that the heat developed by the sliding of two polished surfaces pressed against each other is a direct consequence of the molecular theory, and not a contradiction of it.

A. H.

978. *Fluid Motion.* **H. S. Hele-Shaw.** (Engineering, 67. pp. 28–30, 1899.)—The motion studied takes place between two parallel sheets close together. Stokes has proved mathematically the very remarkable fact that, under these conditions, the lines of flow are the same as would be given by a perfectly frictionless or viscid liquid. The author shows the stream lines experimentally, under various interesting conditions, by introducing coloured liquid at suitable points. The paper contains some fascinating reproductions of photographs. A. Gs.

979. *Speed Indicator.* **W. H. Browne, Jr.** (Electricity, N.Y., 15. p. 35, 1898.)—This instrument, made by the Weston Electrical Instrument Company, comprises a small permanent magnet dynamo with a carefully laminated drum-wound armature, which works with flat side-bearing copper brushes so as to permit rotation in either direction, longitudinal motion of the armature being prevented by set collars. The armature spindle is connected to the machine, a dynamo for example, whose speed it is desired to measure, by means of a flexible "dentist's" shaft of sufficient length to remove the indicator from the magnetic field of the dynamo, the other end of the flexible shaft having a split externally roughened pin which can be pushed into a hole in the end of the dynamo shaft. The instrument is connected to a high resistance voltmeter, and, by properly setting the brushes, a straight-line characteristic can be obtained for either right or left-handed rotation. An accuracy of one revolution in 1,500 can be obtained. It has worked satisfactorily for nine months at the University of Nebraska. C. K. F.

980. *Interferential Measurement of Length and Thickness.* **A. Perot** and **C. Fabry.** (Annal. Chim. Phys. 16. pp. 289–338, 1899.)—During the past two years the authors have published many papers on this subject, all more or less dealing with special applications of the principle. The present paper is more complete, and is useful in that cross references are given to the papers of other workers in the same direction. C. P. B.

981. *Physical Properties of Metals.* **H. F. Parshall** and **H. M. Hobart.** (Engineering, 66. p. 869, 1898.)—The authors give a table of results by various observers of specific resistance, temperature coefficient of resistance, specific heat, tensile strength, and specific gravity of a large number of metals and alloys. W. R. C.

982. *Compressibility of Colloids.* **C. Barus.** (Amer. Journ. Sci. 6. pp. 285–298, 1898.)—The author has investigated the compressibility of colloids in order to throw some light on the elastic properties of glass, geologically considered, and the jelly theory of the ether. In general, colloidal solutions of gelatine and albumen in water have a compressibility very nearly the same as that of water, but without the increase with temperature definitely indicated in the case of water. Some curious phenomena were observed by the author when compressing colloids in a capillary tube by means of a mercury column.

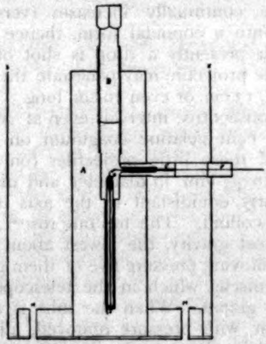
When pressure continually increases (very gradually), the meniscus passes into a conoidal form, thence into an unstable figure, from which presently a drop is shot off, upward. This exceedingly minute projectile may penetrate the whole column of coagulated colloid, 13 cm. or even 20 cm. long. The phenomenon repeats itself at consecutive intervals even at constant pressures. With the 10 per cent. gelatine coagulum, on one occasion, he counted twelve of these little projectiles (on another thirteen, &c.), each less than $\frac{1}{10}$ mm. in diameter and disposed at regular intervals, *i.e.*, nearly equidistant in the axis of the column of coagulated (solid) colloid. The top one rose 12 cm. through the medium and against gravity, the lowest about 1 cm. above the meniscus. On removing pressure five of them gradually dropped back upon the meniscus, which in the telescope soon resembled a bunch of silver grapes. When the tube is allowed to stand vertically overnight with pressure removed, all drops often fall out of the colloidal column before morning. This motion of droplets, up or down, is equally evident to the naked eye.

The phenomenon of the electric spark and the above experiments on the breakdown of mechanical strain as evidenced by the motion of the mercury projectiles are closely analogous. In both cases, there is an originally continuous and solid medium. When breakdown occurs there is in each case motion into the continuous strained medium, through the channel of broken-down, discontinuous, or triturated medium left in the wake. Finally there is recementation resulting in a new continuous medium. We may distinguish between the same solid jelly-like medium in the continuous and in the discontinuous or triturated state, in the sense pointed out above; the former transmits stress like a solid locally, showing rigidity, whereas the latter transmits it like a liquid, and in proportion as the degree of discontinuity is greater, virtually imparts hydrostatic stress. *The same ether may therefore act, as the case may be, either as a liquid or a solid*, just as, in the above experiments with gelatine, one and the same originally continuous and homogeneous body manifests itself in both rôles, under the same conditions. E. E. F.

---

983. *High-Pressure Piezometer.* **A. de F. Palmer.** (Amer. Journ. Sci. 6. pp. 451–454, 1898.)—An apparatus for measuring

very high pressures may be based upon the known relations between the electrical resistance of mercury and the pressure upon it. The apparatus is shown in the diagram, where A is a Bessemer steel cylinder firmly keyed to a cast-iron collar having holes, H H, for anchor bolts. D is a capillary glass tube, 0·1 mm. in internal diameter and 8 cm. long, filled with pure mercury electrically connected with A by a globule of mercury E. A platinum electrode, sealed into the top of D, is soldered to a silk-covered copper wire that passes out of A through a marine glue plug in the tinned steel screw, C, and forms the upper connection with a Wheatstone's bridge. Pressures may be obtained and measured up to 3,500 atmospheres. E. E. F.



---

984. *Action of Electric Currents on Photographic Plates.* **E. Jahr.** (Elektrochem. Ztschr. 5. pp. 197–199, 1899.)—The action of an electric current on a gelatino-bromide dry plate immersed in the developing liquid is observed even with a closed circuit, and increases in intensity with the current and with the E.M.F. The effects are similar to those previously described as being produced by magnetism (see 1899, Abstract No. 837), and cannot well be explained without the accompanying figures.

N. L.

---

985. *Experimental Reproduction of Phenomena Exhibited by Comets.* **T. Bredichin.** (St. Petersburg Acad. Sci. Bull. 8. pp. 173–189, 1898.)—Goldstein has advanced the theory that the tails of comets do not, as is generally supposed, consist of matter thrown out by the head, but that they are luminous phenomena excited in the space surrounding the head by kathode

rays emitted by the sun. This theory is based on certain experiments carried out with kathode rays which closely resemble some of the appearances presented by comets. The author critically examines the new theory, and concludes that it does not rest on a sufficiently sound experimental basis. A. H.

---

986. *Enhanced Lines in Spectrum of α Cygni.* **N. Lockyer.** (Roy. Soc. Proc. 64. pp. 320–322, 1899.)—In previous communications to the Royal Society (Roy. Soc. Proc. 60. p. 475; 61. p. 148; 61. p. 441) the author has described how many of the lines in α Cygni have been found to be due to terrestrial substances, but hitherto unknown because their spectra have only been examined under certain conditions. It is found that when the spectra of the metals, &c., are examined under varying conditions of temperature, such as the oxyhydrogen flame, electric arc and induction spark, certain lines are common throughout, but there are also others which only appear at the higher temperature of the spark. It was pointed out in the earlier papers that the metallic lines in α Cygni were almost entirely these "higher temperature" or "enhanced" lines, the arc lines being exceedingly weak or entirely absent. In August, 1898, the laboratory at South Kensington was enriched by the loan of the large Spottiswoode induction coil, capable of giving a 40-inch spark. With this coil, in conjunction with a very large condenser in parallel on the secondary circuit, the discharge is so luminous that it has been found possible to photograph the spectra under much larger dispersion than before, and this separation of many of the lines from the accompanying gaseous lines renders their measurement more accurate and their detection easier. The elements which have thus far been re-examined are Fe, Mg, Ca, Si, Sr, Va, Ti, Ni, Mn, Cr, Co, Cu. The present state of the problem may be summed up by saying that out of the 307 lines which have been measured in the spectrum of α Cygni between λ 3798·1 and λ 4861·6, 120 coincide with enhanced metallic lines. If, however, only the strongest lines be considered, out of the 40 lines in α Cygni which are over intensity 4 (strongest line in spectrum = 10), 38 are found to have enhanced line representatives. A map of the spectrum of α Cygni showing the lines which have these recently discovered terrestrial coincidences accompanies the paper. C. P. B.

---

987. *Photographic Spectra of Northern Stars.* **F. McClean.** (Phil. Trans. 191. pp. 127–138, 1898.)—This paper contains the discussion of the spectra of 160 stars, including all stars equal to and brighter than the 3½ magnitude, which are visible from the south of England. The photographs have been obtained by the author with a prismatic camera at his observatory at Rusthall.

The whole celestial sphere has been divided into 8 zones, defined with reference to the Galactic plane, and the spectra here discussed fill up 5 of these zones. Reproductions of all the spectra are given with the paper, those in each zone being arranged according to the types suggested by Secchi; Type I, however, being farther subdivided into three parts. The arrangement of the stars in each zone is therefore as follows:—

I. Hydrogen and Helium stars. II. Hydrogen stars. III. Hydrogen and Iron stars. IV. Solar stars. V. Banded spectra, Duner's III.*a*. VI. Fluted spectra (probably Carbon), Duner's III.*b*.

Of special importance is the author's suggestion that certain outstanding lines in the spectra of stars of Division I. might be due to oxygen. This has since been definitely confirmed by the photographs of stellar spectra obtained at South Kensington and Cape of Good Hope (see 1898, Abstract 1208).

Tables showing the characteristics of all the spectra are given, with cross references to the physical classification allotted to them by other authorities, Lockyer, Pickering, Vogel, and Secchi.

C. P. B.

---

988. *Spectrum and Radial Velocity of α Aquilæ.* **H. C. Vogel.** (Berlin Akad. Sitzber. 46. pp. 721–734, 1898.)—α Aquilæ (Altair) is a star having a peculiar spectrum in that all the lines are diffuse. This is commonly explained by supposing the star to be in such rapid rotation on its axis as to cause the spectral lines to be displaced to the red and violet from their true position as explained by Doppler. In addition to the characteristic strong series of Hydrogen lines which place the star in the 1st class, however, Scheiner called attention in 1889 to the presence of fainter but also diffuse bands which agreed in position with "groups of lines" in spectra of stars of the 2nd type (for example, the sun).

To account for this, he put forward two views: one that the effect might be one of the stages of evolution of the star, the other that the star may be a binary, one component being of the 1st class, the companion of the 2nd.

Evidence as to the duplicity of the star was sought by means of photography, both at Potsdam by the author, and at Paris by H. Deslandres, but the results were so discordant in themselves that no definite conclusion could be obtained from them. Vogel, however, had a new series of spectrograms made in 1896 and 1897 with better apparatus, and it is on the measurement of 29 of these that his conclusions are now drawn. The faint diffuse bands described by Scheiner are well shown, and to account for their diffuseness, Vogel made experiments with the solar spectrum by widening the slit, imperfect focussing, &c., and finally thinks that the cause of their appearance in α Aquilæ is really owing to the running together of neighbouring lines owing to their being broadened. Then the question of how the broadening is caused comes forward. Besides the possibility of this being due to motion of the star in the line of sight owing to rotation, we know from laboratory experience that varying conditions of density, temperature, and pressure greatly affect the breadth of spectral lines.

As it has been impossible to detect a periodic motion of the star, it is unlikely that it is a binary, and after many conjectures the following are the author's conclusions: (1) The spectrum really belongs to class I.*a*, 3; (2) the hydrogen lines are broadened by the particular conditions of temperature and pressure of the star, and also by its rotation; (3) in addition, the *atmosphere* of the star contains many metallic lines and tends to resemble stars of class II.*a*; (4) All lines being broadened by rotation, the fine close lines will form faint diffuse bonds, while the strong isolated lines will be diffuse.

A velocity of about 27 kilometres would account for the observed broadening.

The paper concludes with a discussion of the observations made for the radial velocity in the line of sight during 1896 and 1897, for which the mean value is determined to be

$$-32{\cdot}9 \text{ km.} \pm 0{\cdot}3 \text{ or } -4{\cdot}4 \pm 0{\cdot}04 \text{ geographical miles.}$$

The minus sign indicates that the spectrum is displaced to the violet from the normal, and corresponds to the approach of the star towards the earth. C. P. B.

---

989. *Telluric Lines in Solar Spectrum.* **A. de la Baume-Pluvinel.** (Comptes Rendus, 128. pp. 269–274, 1899.)—The series of doublets constituting the B group of the solar spectrum have been proved by Janssen to be due to atmospheric oxygen, by his observations taken between the Eiffel Tower and his observatory at Meudon, and from the summit of Mont Blanc. These observations, however, were only visual, and at the suggestion of Janssen, Baume-Pluvinel repeated the work photographically. The spectrograph was one of considerable power, its components being as follows: The spectrum was obtained by a 4-inch Rowland plane-grating, having a ruled surface 8 cm. × 5 cm. with 14,438 lines to the inch (568 to the mm.). The collimator and camera lenses had focal lengths of 1·10 m. and 1.50 m. respectively, the aperture of each being 0·108 m. A condensing lens, 0·85 m. focal length, fed with light from a heliostat, produced an image of the sun 7·6 mm. diameter on the slit plate. The overlapping of other spectra than the one to be photographed was obviated by a cell containing a solution of aurine placed in front of the slit. Plates of medium rapidity only could be used (the grain of fast plates being too coarse), and these were sensitised for the red by immersion in a bath of cyanine. Well exposed plates

were obtained by 30 minutes' exposure, using the second order spectrum.

Observations were made at Chamounix and on the summit of Mont Blanc on the 5th and 6th of September, 1898. A reproduction is given from the photographs of the B group showing their relative intensity at Paris, Chamounix, and Mont Blanc, which quite well shows their gradual decrease in intensity at the three stations.

The persistence of the lines at the summit of Mont Blanc, at an altitude of 4,810 m., confirms the statement of Janssen that a column of oxygen 120 m. long at atmospheric pressure would suffice to give the bands. The author calculates how high it would be necessary to ascend before the remaining layer of oxygen became less than this amount, and finds it to be at an altitude of about 21,500 m., the pressure being reduced to 53 mm. If it is possible to equip a balloon with an automatic spectroscopic apparatus this question may be settled by a solar spectrum being photographed without the presence of this particular group of lines.

The paper concludes with several observations and suggestions for future work on the matter by M. Janssen. C. P. B.

---

990. *Three Types of Stellar Spectra.* **A. Muller.** (Revue Scientif. 11. pp. 238–242, 1899.)—This is a somewhat popular article, reviewing the growth of stellar spectroscopy, and interesting in that it contains descriptions of much more than is implied in the title. The types of spectra, however, are not brought up to date by any means, nor are the sub-divisions into which Secchi and Vogel classified them taken into consideration. C. P. B.

LIGHT.

991. *Reflection of Light.* **A. Lafay.** (Journ. de Physique, 8. pp. 96–100, 1899.)—The author shows how ready-reckoning scales may be made to show, given the incidence and the index of refraction of the refracting glass, what are the intensities of the reflected and refracted rays and what are the respective proportions of the polarised lights in each. A. D.

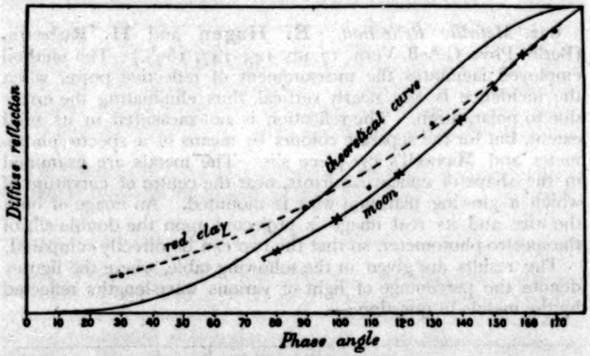
992. *Metallic Reflection.* **E. Hagen** and **H. Rubens.** (Berlin Phys. Gesell. Verh. 17. pp. 143–147, 1898.)—The method employed facilitates the measurement of reflective power when the incidence is very nearly vertical, thus eliminating the errors due to polarisation. The reflection is not measured in its total extent, but for the separate colours by means of a spectro-photometer and Maxwell's eye-piece slit. The metals are examined in the shape of concave mirrors, near the centre of curvature of which a glowing platinum wire is mounted. An image of both the wire and its real image is projected upon the double slit of the spectro-photometer, so that the two can be directly compared.

The results are given in the following table, where the figures denote the percentage of light of various wave-lengths reflected by the metals in question:—

For λ =	450	500	550	600	650	700 μμ
A. Pure metals—						
Silver	90·6	91·8	92·5	93·0	93·6	94·6
Platinum	55·8	58·4	61·1	64·2	66·3	70·1
Nickel	58·5	60·8	62·6	64·9	65·9	69·8
Steel, hardened	58·6	59·6	59·4	60·0	60·1	60·7
Steel, unhardened	56·3	55·2	55·1	56·0	56·9	59·3
Gold	36·8	47·3	74·7	85·7	88·2	92·2
Copper	48·8	53·3	59·5	83·5	89·0	90·7
B. Speculum metals—						
Alloy of Ross (68·2 p.c. Cu + 31·8 Sn)	62·0	62·9	64·0	64·4	65·6	68·1
Alloy of Brashear (do.)	,,	,,	,,	,,	,,	,,
Alloy No. 1 of Schröder (66 p.c. Cu + 22 Sn + 12 Zn)	62·4	62·5	63·4	64·2	65·1	68·0
Alloy No. 6 of Schröder (60 p.c. Cu + 30 Sn + 10 Ag)	61·5	62·5	63·6	65·2	66·6	68·6
C. Glass mirrors—						
Backed with silver ......from	79·3	81·5	82·5	82·5	83·5	84·5
,, ,, ... to	85·7	86·6	88·2	88·1	89·1	89·6
Backed with amalgam	72·8	70·9	71·2	69·9	71·5	72·8

The reflective power increases in general with the wave-length, especially in the case of gold and copper. Iron shows a minimum at 550 $\mu\mu$. E. E. F.

993. *Irregular Reflection.* **C. C. Hutchins.** (Amer. Journ. Sci. 6. pp. 373–380, 1898.)—The reflecting powers of various dull surfaces were studied by means of the thermograph, so as to obtain the total energy reflected. The source of light was the sun. The diagram shows the reflection from a sphere of red clay and from the moon at various phase angles, as compared with the reflection postulated by Lambert's law. The following table shows the albedo of various bodies investigated :—



	Albedo.
Plaster	92·7
Magnesia	47·6
Paper	82·6
Green leaf, upper side	30·2
Green leaf, under side	38·0
Volcanic rock	27·4
Brown soil	31·7

E. E. F.

994. *Brightness of Sources of Light.* **P. Jenko.** (Wied. Annalen, 66. 5. pp. 1182–1185, 1898.)—Taking as unity the intrinsic brightness of a sheet of Bristol cardboard illuminated by a standard candle at 1 metre distance, that of a candle-flame itself is from 12,000–22,000 ; a kerosene lamp-flame, 97,000 ; Violle's unit (platinum at its melting-point), 1,008,000. Several white surfaces were compared, and magnesium carbonate found

to be the best for photometric purposes, because its brightness was the highest and it was most completely free from regular reflexion. R. A. L.

---

995. *Interference Microscope.* **E. Pringsheim.** (Berlin Phys. Gesell. Verh. 17. pp. 152–156, 1898.)—An adaptation of Jamin's refractometer for microscopic work, as first described by Sirks, has been constructed for medical purposes. Jamin's plane-parallel plates are replaced by slightly wedge-shaped plates, which produce a system of interference fringes lying geometrically midway between them. These and the object whose refractive index is to be determined are seen simultaneously in the field of the microscope, and the displacement of the fringes is used for measurement. In practice the displacement is compensated by a body of known refractive index. E. E. F.

---

996. *Inductoscripts.* **J. A. McClelland.** (Cambridge Phil. Soc. Proc. 9. pp. 522–525, 1898.)—The formation of figures on photographic plates by electric discharges may be explained either by direct chemical action, or by chemical action due to light. If the figures are produced by direct chemical action it would point to a difference in the manner in which the positive and negative discharges spread over the plate. If produced by the action of light, the figures would follow the different forms of discharge in the air close to the plate. The author investigates the effect of changing the gaseous medium surrounding the discharging point, and the result of interposing thin plates of different material between the film and the spark. He concludes that the inductoscript is produced principally by the light of the discharge. With a thin plate of mica or glass on the film, the branching lines of the positive figure are only slightly less distinct than when the film is uncovered. When one-half of the thin glass plate is painted black, to make it opaque, the figure is formed only on the portion of film under the transparent half of the cover. Inductoscripts of coins placed on the film can be obtained even with an ebonite plate between the coins and the discharge point; in this case the effect is due to the induced charge. But no effect is produced when the ebonite is between the coins and the film. That the positive and negative figures differ so radically is ascribed to the different forms of discharge in air, in the two cases—positive brush, negative glow. The various results obtained are illustrated. R. A.

---

997. *Rotatory Power of Electrolytes in Dilute Solution.* **E. Rimbach.** (Zeitschr. Phys. Chem. 28. pp. 251–256, 1899.)—Careful measurements are made of the rotatory powers of dextro-rotatory mandelic acid and of its sodium salt. The

specific rotation of the latter is represented by the formula $[\alpha]_D^{20^\circ} = +141{\cdot}23 - 0{\cdot}39796\,q$, where q is the percentage of water in the solution. For mandelic acid, however, the linear formula $[\alpha]_D^{20^\circ} = +212{\cdot}52 - 0{\cdot}5777\,q$ only holds good for solutions containing more than about 3 per cent. of the acid. In more dilute solutions the rotation diminishes much more rapidly. This difference between the two substances corresponds with the fact that whilst the ionisation of the sodium salt is far advanced in the stronger solutions, and therefore changes but little on dilution, that of the free acid is still far from complete even in the most dilute solutions examined. T. E.

---

998. *Rotary Dispersion.* **G. V. Wendell.** (Wied. Annalen, 66. 5. pp. 1149–1161, 1898.)—The rotary dispersion in tartaric acid and in oil of turpentine are here experimentally studied. The specific rotation is determined in aqueous solutions of various strengths of tartaric acid for each of the lines C, D, E, *b* and F, for each 5° temperature between 0° and 50° C. The results are given in tabular form, and some are plotted in curves.

The specific rotations of mixtures of right and left-handed oil of turpentine are measured and found to agree closely with those calculated by Biot's formula, the calculated values, however, being always slightly greater. J. B. H.

---

999. *Anomalous Dispersion of Incandescent Sodium Vapour.* **H. Becquerel.** (Comptes Rendus, 128. pp. 145–151, 1899.)—The author studies the anomalous dispersion by photographing side by side on the same plate a normal spectrum, and the same as deviated by refraction in a prismatic flame containing sodium vapour. The deviation (vertical) y is plotted as a function of x (distance from D_1 or D_2), and it is found that the results can be represented by a formula of the type—

$$y = \frac{k_1}{x} + \frac{k_2}{x-a}$$

where a = distance $D_1 D_2$. Between the rays D_1 and D_2 the deviation-curve possesses a point of inflexion, while beyond D_1 and D_2 on either side it consists of portions of a hyperbola. For waves with vibration-frequencies slightly higher than D_1 or D_2 the corresponding indices of refraction are found to be negative, *i.e.*, these waves travel faster in the sodium vapour than in a vacuum.

The author shows finally how this anomalous dispersion, taken in conjunction with the Zeeman effect, will serve to explain the phenomenon predicted and observed by Voigt (Gött. Nachrichten, November 26, 1898), viz., that a sodium flame placed in a magnetic field and traversed by a beam of polarised light exhibits double refraction in a direction perpendicular to that of the magnetic field.

F. G. D.

1000. *Radiation Phenomena in a Magnetic Field.* **T. Preston.** (Phil. Mag. 47. pp. 165–178, 1899.)—The author continues his remarks on the experiments carried out in strong magnetic fields. He considers that Larmor's electromagnetic theory furnishes an explanation of the results obtained. Consider the simple case of a single ion describing an elliptic orbit under a central force directly proportional to the distance: this electric charge, under the action of a magnetic field, has its elliptic orbit forced into precession round the direction of the magnetic force, this being a first approximation. If N be the natural frequency of revolution of the particle in its orbit and n the frequency of revolution of the orbit in its precessional movement, the combined movement is equivalent to the coexisting motions of frequencies $N+n$, N, and $N-n$ respectively. When n is small compared with N, so that its square may be neglected, the equations of motion of the particle in the revolving orbit become identical with those of the moving ion in the magnetic field. This simple theory predicts that a single spectral line should be converted into a triplet by the action of the magnetic field, and that the constituents of this triplet should be plane polarised when viewed across the lines of force. It explains the cause of the tripling as the forced precession of the ionic orbits round the lines of magnetic force, and it assigns a dynamical cause for this precession in the action of the magnetic field on the ionic charge moving through it.

Stoney gave the explanation of the phenomena in 1891, six years before the effects were observed. His aim was to explain the occurrence of doublets and equidistant satellites in the spectra of gases, without reference to the influence of a magnetic field, which was not then known to exist. He considered what the effect would be on the period of the radiations from a moving electron if subject to disturbing forces. Perturbations seem clearly to be sufficient to account for all the phenomena. Still, Stoney's explanation of natural doublets is subject to serious difficulty, from the fact that the two lines of a given doublet behave in different ways, as if they arose from different sources rather than from the perturbation of the same source.

According to the electromagnetic theory, the separation, $\delta\lambda$, of the side lines of a magnetic triplet should vary directly as λ^2 as we pass from line to line of the same spectrum. It is possible that the lines of any one substance may be thrown into groups for each of which $\delta\lambda$ varies as λ^2, each of these groups being produced by the motion of a single ion. The number of different kinds of ions in the atom or molecule may thus be determined. Investigation, so far as carried, confirms this speculation. The quantity e/m or $\delta\lambda/\lambda_2$ is the same for corresponding lines in homologous spectra, and moreover the *character* of the magnetic effect is also the same for corresponding lines. J. J. S.

1001. *Uranium Radiation.* **E. Rutherford.** (Phil. Mag. 47. pp. 109–163, 1899.)—The nature of the radiation emitted by uranium and its compounds has been investigated with special reference to the electrical conduction produced. Very similar effects are produced in gases by uranium and Röntgen radiation. The author finds no evidence to show that polarisation or refraction takes place: in this respect he differs from Becquerel, the discoverer of the uranium radiation, who concludes that polarisation and refraction do occur. The theory of ionisation, which supposes that the rays in passing through a gas produce positively and negatively charged particles in the gas, and that the number produced per second depends on the intensity of the radiation and the pressure, furnishes a satisfactory explanation of the electrical conductivity produced by uranium radiation.

Experiments are described which show that uranium radiation is complex: in it there are present at least two distinct types of radiation—one that is very readily absorbed, called by the author the α radiation, and the other of a more penetrative character, termed the β radiation. There are indications that the β radiation is approximately homogeneous; this type passes through the substances tried with greater facility than the α radiation. In experiments with different uranium compounds it was found that the amount of the α radiation depended chiefly on the surface of the uranium compound, while the β radiation depended also on the thickness of the layer. The rate of leakage of electricity between two metal plates kept at different potentials and placed 4 cm. apart, on one of which metallic uranium or a compound of uranium was spread, was measured by means of an electrometer. The rate of leakage due to the β radiation is, as a rule, small compared with that produced by the α radiation. The α radiation is strongly absorbed by gases, while the β radiation is only slightly so. In the case of photographic action it is found that the β radiation is the effective variety. There is a great difference in the power of penetration of the two types of radiation. The transparency of aluminium for the β radiation is over 100 times as great as for the α radiation. The opacity of the metals aluminium, copper, silver, platinum for the β radiation follows the same order as their atomic weights. Platinum has an opacity 16 times as great as aluminium. The α radiation from uranium and its compounds is rapidly absorbed in its passage through gases. The absorption for hydrogen, air, and carbonic acid was determined, and was found to be least in hydrogen and greatest in carbonic acid. The results obtained on the variation of leakage with distance may be simply interpreted on the theory of ionisation of the gas through which the radiation passes. The absorption of the β radiation is comparatively slight. The absorption of the α radiation increases with increase of pressure and very approximately varies directly as the pressure. In one experiment it was found that the rate of leakage between two plates reached a maximum when the gas was at a pressure of less than half an atmosphere and then decreased; at 10 cm. pressure the rate of leakage was still greater than at atmospheric pressure. The rate of leakage increases at first with diminution of pressure. There appears to be approximately the same amount of ionisation in all gases for the same absorption of energy. On comparing the velocities of the ions under similar conditions, in Röntgen and uranium conduction, it appears that the ions in the two types of conduction are the same.

The cause of the radiation continuously emitted by uranium and its salts remains unknown. The results hitherto obtained point to the conclusion that uranium gives out types of radiation which, as regards their effect on gases, are similar to Röntgen rays and the secondary radiation emitted by metals when Röntgen rays fall upon them. J. J. Thomson has suggested that the regrouping of the constituents of the atom may give rise to electrical effects such as are produced in the ionisation of a gas. The energy spent in producing uranium radiation is probably extremely small, so that the radiation could continue for long intervals of time without much diminution of the internal energy of the uranium.

J. J. S.

1002. *Radio-active Bodies*. **H. Becquerel.** (Comptes Rendus, 128. pp. 771–777, 1899.)—The author's earlier experiments, according to which uranium rays were regularly polarised, reflected, and refracted to some extent, are not confirmed by later experiments on uranium, thorium, radium, and polonium compounds. The reflection, according to the more recent photo-plate *clichés*, seems to be diffuse and to be complicated with secondary radiations; but it remains unexplained why the earlier *clichés* came out as they did. Radiations from polonium are much absorbed by paper and mica, quartz and spar, while those from radium are much less so. The uranium preparations of May, 1896, have lost very little of their radio-active power. Such substances seem, like a magnet, to contain a store of energy expended in giving them their present condition; and, as in some substances rendered phosphorescent by heat, the process of giving out this energy, though constant for some years, is very slow. It has not been found possible by any physical means to bring about any appreciable variation in the intensity of the radiation emitted.

A. D.

1003. *Absorption of Röntgen Rays*. **J. H. Gladstone** and **W. Hibbert.** (Chem. News, 78. pp. 199–200, 1898; Rep. Brit.

Assoc. 1898, pp. 835–836.)—Further experiments, confirming the conclusion (Brit. Assoc. 1896, 1897) that absorption of Röntgen rays by a compound body is almost wholly dependent upon the absorption exercised by its constituents and is little, if at all, modified by their physical condition, or by change of atomicity, or by other differences of combination. The small differences of result—*e.g.*, uncombined carbon absorbing a little more than an equivalent quantity of any of the hydrocarbons—may be due to the presence in the Röntgen radiations of small quantities of rays which, though they have passed through aluminium foil, have properties somewhat analogous to ordinary light. A. D.

1004. *Transformations of Röntgen Rays.* **Hurmuzescu.** (Comptes Rendus, 128. pp. 422–425, 1899.) (See 1898, Abstract No. 1132, and 1899, Abstract No. 431.)—There appears to exist a relation between the emission of rays transformed by a given body and their absorption by the same body, the rays being absorbed more readily by it than by other bodies. This selective absorption manifests itself in the discharging effect produced by the transformed rays. Two electroscopes identical in every respect, except that the cage of one consisted of zinc and that of the other of lead, were charged to the same potential, and subjected to the action of rays transformed by lead (the transformed rays alone being allowed to enter the cage, and not the X-rays producing them). It was found that the time required to diminish the deflection of the zinc-cage electroscope by a certain amount was 29·8 secs., while the time for the lead-cage electroscope was 51 secs. These phenomena point to the fact that the effects produced are due to a transformation of the X-rays (into rays of greater wave-length), and not to simple diffusion. A. H.

1005. *Transformation of Röntgen Rays by Matter.* **G. Sagnac.** (Écl. Électr. 18. pp. 41–48, 1899.)—An interesting *résumé*, with polemical digressions, of the author's work on this subject and that of others. A. D.

HEAT.

1006. *Dilatation of Perfect Gases.* **D. Berthelot.** (Comptes Rendus, 128. pp. 498–500, 1899.)—The author discusses the coefficient of dilatation at constant pressure, denoted by γ, common to gases. The generally accepted value has been $1/\gamma = 273{\cdot}14$. Some of the German physicists have recently, says the author, proposed to raise this figure to 274, or even 274·5. He refers to recent researches of Chappuis, Amagat, Leduc, and Sacerdote, made with regard to hydrogen under pressures from 1 millimetre of mercury to 100 atmospheres. These, he says, restore the classical number 273·14, or 273. Some interesting relations are mentioned arising from the fact that for hydrogen γ in the perfect gas is greater, for other gases less, than α, the corresponding coefficient under atmospheric pressure. S. H. B.

1007. *Characteristic Equation for Fluids.* **E. H. Amagat.** (Comptes Rendus, 128. pp. 538–542, 1899.)—A new form of the characteristic is arrived at for carbonic acid, viz.:—

$$\left[p + \frac{v - \mathrm{T}\left\{a + m(v-b) + c(v-b)^{-1}\right\}}{kv^r - \alpha + n\sqrt{\left\{(v-\beta)^2 + d^2\right\}}}\right] v = \mathrm{RT},$$

where—

$a = 0{\cdot}0000014566$ $\quad \mathrm{R} = 0{\cdot}00368$ $\quad \alpha = 0{\cdot}000000198$
$b = 0{\cdot}000947$ $\quad k = 44{\cdot}6$ $\quad \beta = 0{\cdot}0018425$
$c = 0{\cdot}00000000028832$ $\quad r = 2{\cdot}85$ $\quad d = 0{\cdot}0002679$
$m = 0{\cdot}0018$ $\quad n = 0{\cdot}0006.$

The history of the construction of this formula, which satisfactorily represents the results obtained with pressures varying from 1 to 1000 atmospheres and temperatures ranging from 0° to 258°, is given at length. R. E. B.

1008. *Regnault's Calorie and the Specific Volumes of Steam.* **G. P. Starkweather.** (Amer. Journ. Sci. 7. pp. 13–33, 1899.)—Regnault's determination of the specific heat of water and the total heat of steam, together with the results of ten other experimenters, are first discussed at length. It is found that Regnault's thermometric scale was that of the air-thermometer; that his calorie represents the specific heat at 15° on this scale; that with this unit his experiments give 1·00358 for the mean specific heat between 0° and 100°, and for the "heat of water,"

$$\begin{aligned} h &= t + 0{\cdot}00000929\, t^2 + 0{\cdot}000000265\, t^3 && \text{above } 100^\circ \\ &= 1{\cdot}00449\, t - 0{\cdot}0001904\, t^2 + 0{\cdot}000001813\, t^3 && \text{below } 100^\circ; \end{aligned}$$

that the "total heat of steam" is best represented by

$$\begin{aligned} H &= 603{\cdot}2 + 0{\cdot}356\,t - 0{\cdot}00021\,t^2 \quad \text{above } 100^\circ \\ &= 598{\cdot}9 + 0{\cdot}442\,t - 0{\cdot}00064\,t^2 \quad \text{below } 100^\circ. \end{aligned}$$

The difference between these quantities gives the latent heat, from which, with Rowland's value of J, viz., 427·03 kgm. at Paris at 15°, the following values of the specific volumes of dry saturated steam have been calculated:—

0°	208·94	...	...	...	...	...	...
10	107·88	60	7·6703	110	1·1973	160	0·30278
20	58·505	70	5·0320	120	0·88099	170	0·23982
30	33·198	80	3·3942	130	0·65948	180	0·19216
40	19·637	90	2·3464	140	0·50152	190	0·15566
50	12·063	100	1·6587	150	0·38707	200	0·12739

The error of these numbers cannot be more than 0·5 per cent. on the score of the value of J, nor more than 0·6 per cent. at 200°, 0 per cent. at 100°, 0·5 per cent. at 0° from uncertainty as to the latent heats; below 40° the numbers are entirely uncertain, owing to errors in Regnault's values of p and dp/dt.

The volumetric experiments on superheated steam made by ten observers, in which an unusual amount of difficulty occurs by reason of condensation on the walls of the containing vessel, are then minutely discussed with the conclusion "that all our knowledge concerning the density of steam is limited to the saturation line, the experiments on superheated steam presenting discrepancies which cannot be reconciled." R. E. B.

1009. *Thermometric Fixed Point and Normal Temperature.* **W. Meyerhoffer** and **A. P. Saunders.** (Zeitschr. Phys. Chem. 27. pp. 367–368, 1898.)—The transition-temperature of Na_2SO_4 is lowered from 32·35° to 17·9° by admixture with NaCl in the proportion of their molecular weights. This lower point is convenient to take as a *normal* "temperature of the room," being easily and cheaply attained and lying within the range of room-temperatures ordinarily occurring. R. E. B.

1010. *Transition-temperatures as Thermometric Fixed Points.* **T. W. Richards** and **J. B. Churchill.** (Amer. Acad. Proc. 34. pp. 277–280, 1899.)—The authors claim priority over Meyerhoffer and Saunders (see preceding Abstract) in suggesting this use of transition-temperatures. As normal temperature for graduating flasks, &c., they prefer one nearer 20° than 18°, at least for America, such, indeed, as is given by sodium chromate

(19·6°). They have determined the following transition-temperatures on the hydrogen thermometer, but give them only as approximations subject to future revision. (On the mercury thermometer the temperatures are 0·105 higher.)

Sodic chromate.........	$Na_2CrO_4 . 10\ H_2O$	19·6
Sodic sulphate	$Na_2SO_4 . 10\ H_2O$	32·379
Sodic carbonate	$Na_2CO_3 . 10\ H_2O$	35·1
Sodic thiosulphate ...	$Na_2S_2O_3 . 5\ H_2O$	48·0
Sodic bromide	$NaBr . 2\ H_2O$	50·7
Manganous chloride...	$MnCl_2 . 4\ H_2O$	57·8
Strontic chloride	$SrCl . 6\ H_2O$	61·0
Sodic phosphate	$Na_3PO_4 . 12\ H_2O$	73·4
Baric hydroxide	$Ba(OH)_2 . 8\ H_2O$	77·9

R. E. B.

1011. *Platinum Thermometry.* **H. L. Callendar.** (Phil. Mag. 47. pp. 191–222, 1899.)—In this paper a historical summary is given of the work which led up to the employment of platinum thermometers. Various formulæ and methods of reduction are discussed and the author explains his proposed standard notation and nomenclature. J. J. S.

1012. *Platinum Thermometry.* **E. B. H. Wade.** (Cambridge Phil. Soc. Proc. 9. pp. 526–529, 1898.)—In the method adopted by Callendar and Griffiths for measuring temperatures by platinum thermometers, equal increments of resistance do not represent equal increments of temperature; the equation connecting resistance with temperature is by them assumed to be a parabola with inclined axes, and this involves rather troublesome calculations. The author shows that the bridge can be arranged in such a manner as to avoid these calculations. The fixed arms of the bridge are chosen equal to one another. The adjustable arm consists of two sets of coils in parallel, and by whatever amount the resistance of one set is increased that of the other is diminished; their series resistance is therefore constant. It is proved that, under these conditions, if this series resistance is rightly chosen, the bridge-readings are now linear functions of the temperature.

Incidentally, the author points out a curious analogy between the action of such a shunt and the action of impurities in a wire. It is regarded by many as not improbable that in a wire of perfectly pure platinum the resistance might be a linear function of the temperature: no shunt would then be necessary to give direct bridge-readings. Thus the action of the impurity in the wire is similar to a shunt. R. A.

1013. *Kinetic Theory of Polyatomic Gases.* **F. Richarz.** (Wied. Annalen, 67. 3. pp. 702–706, 1899.)—A double application of the virial equation leads to the conclusion that $\frac{3}{2}pv$ is equal to the kinetic energy of the motion of translation of all the molecules contained in the volume in question. Avogadro's law further implies that every molecule has the same mean kinetic energy of translation. If a polyatomic gas is compared with a monatomic gas like mercury vapour at the same pressure and temperature, it is apparent that the mean kinetic energy of every molecule of it must be equal to that of a mercury atom. But in a monatomic gas the motions of a molecule and of an atom are identical. Hence in a polyatomic gaseous molecule the total mean kinetic energy of a single atom must be equal to the mean kinetic energy of translation of a molecule. This simple deduction of Boltzmann's law is only possible, however, if it is admitted that the kinetic energy of the atom is the measure of temperature.

The author further points out that he had, before Staigmüller's work appeared, deduced Dulong and Petit's law by an application of the virial function, and that his deduction indicated the substances in which a deviation from Dulong and Petit's law could be expected. E. E. F.

1014. *Thermodynamics of Luminescence.* **E. Wiedemann.** (Wied. Annalen, 66. 5. 1180–1181, 1898.)—As Wesendonck (see 1898, Abstract No. 133) appears to have misunderstood the author, Wiedemann repeats his opinion that apparent exceptions to the second law of thermodynamics only occur in cases of luminescence because the luminescent substance is to be regarded as an intermediary between a hotter and a colder body.

R. A. L.

1015. *Absolute Temperature.* **K. Schreber.** (Wied. Annalen, 66. 5. pp. 1186–1190, 1898.)—The author defends a point of his theory (see 1898, Abstract No. 1328) against Wiedeburg.

He also claims for his (geometrical) scale of temperatures the name "absolute," rather than for Lord Kelvin's. The scale is defined by—

$$\theta_1 - \theta_2 = \frac{1}{\log 2} \cdot \log \frac{Q_1}{Q_2}$$

where Q_1 Q_2 are the quantities of heat occurring in a reversible cycle between the temperatures θ_1 θ_2. In Kelvin's scale the two standard temperatures, and therefore the value of the degree, are defined by means of the properties of a particular substance, viz., water; Schreber claims to have avoided this. R. A. L.

1016. *Kirchhoff's Law.* **W. Voigt.** (Wied. Annalen, 67. 2. pp. 366–387, 1899.)—The proportionality between thermal emission and absorption has not yet been theoretically explained. The author amplifies the mathematical theory of radiation so as to include the process of emission. He supposes the radiating body to have the shape of a plane-parallel plate excited homogeneously in parallel layers, and emitting plane waves in a direction normal to its surface. He altogether fails to derive Kirchhoff's law from theoretical considerations dealing only with regular trains of waves, and points out that in practice it is only irregular motions that are dealt with. He therefore modifies his theoretical assumptions by supposing that the plane-parallel plate is divided into a very large number of thin and equal layers which are excited in an incoherent manner. The approximation to Kirchhoff's law then becomes very close on introducing a simple relation connecting the parameters of the optical excitations with certain optical constants of the medium. The conceptions arrived at may be applied to the consideration of an isotropic body placed in a magnetic field, with the result that the excitations are independent of the field intensity, and that the Zeeman effects are solely due to a change in the vectors of oscillation. E. E. F.

1017. *Emissivity of Platinum.* **J. E. Petavel.** (Phil. Trans. 191. pp. 501–524, 1898.)—The results of this research have already been noted (see 1898, Abstract No. 1326); the apparatus used is now described. Radiation was obtained by a thick platinum wire, since thin ones give irregular results; the current through it and the E.M.F. near its ends were measured, to determine simultaneously the temperature and power spent. Callendar's formula for the temperature extrapolated up to 1500° was found to agree with Violle's measurement of the melting-point of palladium. The hot wire was placed inside a glass cylinder in which the air pressure could be varied, or which could be filled with steam, CO_2, &c. To determine this radiation, a bolometer was constructed by welding a thin Pt plate on to a thick Ag one, rolling out, and dissolving off the silver; in this way a thickness of 0·00011 cm. was obtained. One face was platinum blacked, the other was backed by a mirror. The instrument was very sensitive, but of somewhat inconstant zero: greater constancy was obtained by evacuating the box containing it, and admitting the radiation through a quartz plate. (The author does not say in which experiments the quartz plate was used, nor whether the use of it sensibly affects the apparent law of radiation obtained.) A candle at 1 m. produced 360 scale divisions deflection. The results on the law of radiation agree fairly with those of Bottomley, Schleiermacher, and Paschen, and confirm Weber's formula. R. A. L.

ELECTRICITY.

1018. *Magnetic Force in Solenoids.* **C. C. Farr.** (Roy. Soc. Proc. 64. pp. 192–203, 1898.)—"Expressions are arrived at, in terms of zonal harmonics and their first derivatives, by which the values of the two components of the magnetic force may be calculated for any point in the interior of a coil."

EDITOR.

1019. *Contact Force.* **J. Brown.** (Roy. Soc. Proc. 64. pp. 369–374, 1899.)—A small copper-zinc condenser was placed in a glass tube together with metallic potassium. The tube was filled with nitrogen at a reduced pressure of about 5 mm. Three sets of measurements of the contact E.M.F. were taken, lasting six months, one and a half years, and seven and a half years respectively. The first set showed a reduction from 0·56 volt to 0·33 volt in 181 days, but this was not confirmed by the other two experiments. Consequently the results do not support a chemical theory of contact force. W. R. C.

1020. *Contact Electrification.* **A. Coehn.** (Wied. Annalen, 66. 5. pp. 1191–1193, 1898.)—The author in a former paper (see 1898, Abstract No. 505) propounded the law that bodies of high dielectric capacity assume a positive charge in contact with insulators of a lower dielectric capacity. Heydweiller tested the applicability of this law to the contact of metals and liquids (see 1899, Abstract No. 273), and concluded that it did not apply, or at least that in this case other properties than the dielectric constant played an important part. In the present note the author emphasises the fact that the law is not applicable to the contact of metals and liquids, owing to the disturbing influences of solution, oxidation, and evolution of gas at the metals. By taking special precautions to avoid these as much as possible, he has, however, found that pure metals are positive with respect to water. Further particulars are promised in a future paper. J. B. H.

1021. *Electric Discharge.* **J. Precht.** (Wied. Annalen, 66. 5. pp. 1014–1018, 1898.)—The author has repeated Faraday's experiments on discharge in air, between pointed and plate electrodes, using the alternative path method, just as Faraday did, with the point electrode positive in the one spark-gap and negative in the other. As generators he used any one of the following: A 20-plate Töpler machine; a Voss machine with 2 plates; a Holtz machine; a small Wimshurst machine, and an induction coil. With these different generators some remarkable differences in the discharges were noted. With the large machine the discharge always took place between the positive point and negative plate. With the smaller machines the discharge is almost entirely between the negative point and positive plate, and with the induction coil the reverse. Measurements of the differences of potential between the electrodes in each case confirm the results.

The conclusion is that the differences can in no way be attributed to differences in positive and negative electricity, but must be attributed to the output of the generator and the magnitude and rate of variation of the potential at the electrodes.

J. B. H.

1022. *Discharge Streams.* **J. E. Moore.** (Amer. Journ. Sci. 6. pp. 21–40, 1898.)—The author treats the electric discharge in a vacuum tube from the point of view of the kinetic theory of matter. He regards the study of the elementary mechanical transactions in electrical discharge as not merely a study of some interesting light phenomena, but as a study of the elementary actions in electrical conduction, not only in gases, but in liquid and solid conductors as well. A close analogy may be traced between the distribution of the lines of flow of heat from a hot body, and the lines of motion taken by discharge stream. An experiment is described which brings this out in a practical manner. The cups of a Crookes radiometer when heated rotate with the concave side forward. They do the same when charged to a high potential. When the bulb is thoroughly exhausted by means of a Sprengel pump, the movable system is put in connection with one terminal of the two-part commutator for rectifying the alternating potential-difference of the secondary of the induction coil. The cups are seen to rotate, concave side forward. On disconnecting the electrical source, and grasping the bulb in the hands, the cups immediately begin to rotate in the opposite direction, and continue to rotate for a short time before coming to rest. The electrification of the walls is very troublesome, but when they are carefully discharged after each operation, the above direction of rotation, upon connecting the movable system with a source of high potential, has been observed, whether the potential of the source be positive or negative in sign.

The author investigates more particularly the return stream which replaces the matter projected from the kathode.

The return stream from the walls of the tube (travelling in straight lines) must leave the walls at a greater distance from the kathode, in order to reach the central portion of the cylindrical surface, by coming over the sides, than by entering the kathode from the ends. The electrification of the walls of the tube falling off very rapidly from the kathode, the velocity of those parts of the return stream which spring from points on the walls of the tube near the kathode must be very different from the velocity of those parts coming from points remote from the kathode. The cross-section of the discharge stream from a cylindrical kathode ought, then, to be found to diminish more rapidly (with decreasing molecular density), parallel to the axis of the cylinder, than along the arc of the curved surface. E. E. F.

1023. *Carbon Coherer.* **T. Tommasina.** (Comptes Rendus, 128. pp. 666–667, 1899.)—When brass filings are suspended in water and a feeble current is sent through, the filings form chains, which break up subsequently, not into individual particles, but into short rods. The author attempted to find a substance which would under similar circumstances break up into particles. He succeeded in forming carbon chains 12 to 15 mm. long, and produced a carbon coherer which had a sensitiveness as great as that of the best metallic coherers. They have the advantage of losing their conductivity with the least shock, and, under favourable conditions, the interruption of the current through the coherer suffices to restore the original resistance. Another efficient type of carbon coherer may be made by introducing two cylindrical arc carbons into a glass tube, in which they are held by rubber stoppers in such a position that their ends are lightly in contact. Such a coherer is extremely sensitive, and does not easily get out of order. The author employed this coherer to test whether any extra-currents were induced in the human body by electric oscillations. On holding the terminals between his thumbs and forefingers, he found that the coherer acquired a high conductivity by the impact of electric waves. E. E. F.

1024. *Electro-Thermal Relations.* **E. Riecke.** (Wied. Annalen, 66. 5. pp. 1199–1200, 1898.)—The author in this note mentions that after his work on this subject (see 1899, Abstract No. 299) was in print he received from Van Everdingen a memoir on the galvanometric and thermomagnetic phenomena in bismuth which showed the assumption made of the equal displacement velocities of positive and negative electricity to be incorrect. The author also points out two other oversights in his work above mentioned. S. H. B.

1025. *Thévenin's Theorem.* **J. B. Pomey.** (Écl. Électr. 18. pp. 121–123, 1899.)—This paper discusses the application of Thévenin's Theorem to proving Mance's method of measuring the internal resistance of a battery, and obtaining the best conditions for sensibility, but does not well admit of abstracting. E. C. R.

1026. *Effect of Heat and Moisture on Dielectrics.* **E. Letheule.** (Écl. Électr. 17. pp. 439–442, 1898.)—A section of the apparatus used by Chester and Crellin of the University of Illinois is given, and the curves they obtained summarised and reduced to ohms per cubic centimetre. M. O'G.

1027. *Dielectric Polarisation and Hysteresis.* **W. Schaufelberger.** (Wied. Annalen, 67. 2. pp. 307–324, 1899.)—Ellipsoids of ebonite or paraffin are suspended bifilarly between the vertical plates of a Kohlrausch condenser. All the experiments show a considerably increased damping of the oscillations on charging the condenser. This means that a certain expenditure of energy is necessary in order to keep the direction of polarisation parallel to the electric lines of force. This necessitates a departure from Maxwell's fundamental formula connecting displacement with electric force. The experiments are rendered difficult by the great disturbing effect of moisture. In paraffin, the consumption of energy is proportional to the square of the force. This accords with previous results, except those of Arnò, who found an index of about 1·8 instead of 2. Ebonite is a very imperfect dielectric in comparison with paraffin, and no well-defined results have been obtained for it. E. E. F.

1028. *Dielectric Constants and Density.* **D. Negreano.** (Comptes Rendus, 128. pp. 814–815, 1899.)—The author draws attention to the fact that the formula $\frac{k-1}{(k+2)\,d}$=constant (where k is the dielectric constant and d the density), which is known by the name of the Mossotti-Clausius formula, is not due to these investigators, but was established theoretically by Lorentz in 1880, and experimentally by himself in 1887. A. H.

1029. *Measuring Small Capacities.* **J. J. Borgman** and **A. A. Pétrowsky.** (Comptes Rendus, 128. pp. 420–422, 1899.)—One terminal of a Ruhmkorff coil is earthed or remains isolated, while the other is attached to a movable terminal which may be slid along a groove cut in a block of paraffin and filled with water. At the ends of the groove are platinum electrodes, which are connected to a spectrum-analysis Geissler tube. On starting the coil, the tube glows without showing any polarity. A displacement of the movable terminal along the groove changes the intensity of the glow, and for a certain position of this terminal, a dark space, termed by the authors a *node*, appears in the capillary portion of the tube. The node may be brought into the middle of the tube by suitably adjusting the position of the movable electrode. This position depends on the capacities of the conductors which connect the electrodes of the tube to the ends of the groove, and the phenomenon may be utilised for the comparison of very small capacities, by connecting the unknown capacity to one of the conductors, and then attaching a known variable capacity to the other, and adjusting it until the node is once more brought back to the middle of the capillary portion of the Geissler tube. Another method is to displace the movable terminal along the groove until the same result is obtained; the displacement is, within certain limits, proportional to the capacity. The author states that by this means capacities as small as a fraction of an electrostatic c.g.s. unit may be measured. A. H.

1030. *Test to Faults.* **A. Jordan** and **W. Schonau.** (Elect. Rev. 44. p. 233, 1899.)—Referring to Elect. Rev. October 12, 1894, it is possible to modify the Earth Overlap Test to localise a fault without its being necessary for the two terminal stations to communicate with each other after each reading. Diagrams are given showing how to use Mance's method in this conjunction where the fault is liable to polarise. M. O'G.

1031. *Experiments with Wehnelt Interrupter.* **H. Pellat.** (Comptes Rendus, 128. pp. 732–734 and 815–817, 1899.)—When the interrupter is connected direct across a 110-volt circuit, the current is found to be 4 to 5 amperes. On disconnecting and joining it up in series with the primary of an induction coil (25 cm. spark), the current is found to exceed 25 amperes, a flame stretching across the secondary spark-gap. Thus the mean value of the current is increased by the introduction of an impedance into the circuit of the interrupter. If now while the coil is at work its primary be suddenly short-circuited by a stout piece of copper wire, the secondary sparks cease immediately, but the primary current remains at its high value during a few seconds, after which it suddenly drops to 4 or 5 amperes. If while the latter current is passing, the short-circuit be removed, so that the primary of the coil is once more thrown into the circuit of the interrupter, the current remains feeble, and there is no sparking across the secondary terminals, even when they are gradually brought nearer together until almost in contact. This condition will persist for any length of time. It never arises spontaneously, for if the circuit be momentarily broken and re-established, a flame immediately shoots across the secondary spark-gap, and the primary current rises to over 25 amperes. The author attempts to develop a mathematical theory of these phenomena, and arrives at the conclusion that the inductance of the circuit and the reaction

of the secondary coil have only an indirect effect in imparting greater stability to one or other of the two possible conditions under which the interrupter may receive current from the mains.
A. H.

1032. *Electrical Measuring Instruments.* **C. T. Child.** (Amer. Electn. 10. pp. 510–512, 1898.)—Instructions are given for making a simple voltmeter, ammeter, wattmeter, and energy integrating meter.
W. R. C.

1033. *Tesla's Interrupter.* (Elect. Rev. N.Y. 33. p. 247, 1898.)—The patent specification is given. The interruptions are obtained by a stream of mercury impinging upon a rotating disc having projecting teeth. The interruptions take place in a gas under pressure, thus permitting a much higher frequency than would otherwise be possible.
W. R. C.

1034. *Carbon-Consuming Batteries.* **A. J. Rogers.** (Elect. Rev. N.Y. 34. p. 56, 1899. Paper read before the North-Western Electrical Association, Milwaukee.)—A short account of recently suggested carbon-consuming cells.
W. R. C.

1035. *Harmonic Analyser for Alternate Currents.* **T. des Coudres.** (Berlin Phys. Gesell. Verh. 17. pp. 129–132, 1898.) —The author proposes to construct an analyser on the following principle: The current $F(x)$ is sent through the fixed coil of an electrodynamometer. The movable coil is connected to the terminals of a sine inductor, whose period is a submultiple T/n of the main period. The couple between the two coils is proportional to the product of the two currents, *i.e.*—

$$n \sin (nx) F(x)$$

if the time is chosen so that the sine inductor current just changes sign at time O. The mean couple to be compensated by the torsion head is—

$$a_n = k \, . \, n \, \frac{1}{\pi} \int_0^{2\pi} F(x) \sin (nx) \, dx \, .$$

where k is the constant of the apparatus. But that is the coefficient A_n of the Fourier series for $F(x)$, down to the factor kn:—

$$A_n = \frac{1}{\pi} \int_0^{2\pi} F(x) \sin (nx) \, dx$$

$$a_n = kn \, A_n \, .$$

On turning the coil of the Kohlrausch sine inductor through 90°, so that its current for $x = \pi/2$ is zero, the dynamometer reading becomes—

$$\beta_n = k \,.\, n \,.\, \frac{1}{\pi}\int_0^{2\pi} \mathrm{F}(x) \cos (nx)\, dx$$

$$\beta_n = kn\, \mathrm{B}_n\,.$$

Hence it is only necessary to let the sine inductor run successively to frequencies, 1/T, 2/T, 3/T, and to read the successive dynamometer deflections α and β, to obtain successive terms in the Fourier series. E. E. F.

1036. *Hysteresis Errors in Measuring Instruments.* **W. M. Stine.** (Elect. World, 33. pp. 200–202, 1899.)—The author first describes a modification of the Wheatstone-Kelvin rheostat which was used in making the experiments, enabling a potential difference to be varied with perfect continuity. The experiments were made on several voltmeters of different commercial patterns all containing a soft iron movable armature either singly or in combination with a fixed piece of soft iron for opening out certain parts of the scale.

The voltmeters were put in parallel with a Weston voltmeter, an instrument possessing no hysteretic error, the voltage being uniformly increased from zero up to the maximum reading of the instrument, and then decreased back to zero. In all cases a marked loop is found between the ascending and descending readings. In some of the cases the maximum voltage was kept on for ten minutes before the descending readings were taken, this with some of the instruments shows evidence of a magnetic lag, the deflection creeping up to a higher value when the impressed voltage remains at a fixed value. Readings were also taken with a key in the voltmeter circuit which was broken between every reading; this method gives much smaller hysteretic errors, the ascending and descending curves being nearly coincident. The paper is illustrated with curves giving results obtained.

The conclusions arrived at by the author are that this type of instrument is eminently unsuited for the laboratory. No matter how carefully the instrument is calibrated the subsequent readings cannot be relied on, for the error is not constant, but varies with conditions which cannot be accurately ascertained. With alternating currents they are more reliable, yet hysteresis is not wholly eliminated, and they cannot be considered accurate. E. C. R.

1037. *Determination of H by Unifilar and Bifilar Magnetometers.* **H. Wild.** (St. Petersburg Acad. Sci. Bull. 8. pp. 239–252, 1898.) — In careful measurements carried out by both methods the author found a constant difference between the results of the two methods, which was about ten times the probable error of an observation, the higher value being always obtained with the bifilar instrument. With a unifilar magnetometer, the horizontal intensity is (using the method of sines and neglecting corrections) given by

$$H_u = \frac{\pi}{T}\sqrt{\frac{2I}{d^3 \sin \theta}}$$

while the formula for the bifilar instrument is

$$H_b = \sqrt{C \cdot mg}$$

where C is a constant, m the mass of the suspended body, and g the acceleration due to gravity.

The corrections to be applied in the two cases are essentially different. In finding T, the resistance due to viscosity of the air must be taken into account, and the corresponding correction will render H_u greater. There is a further correction due to the inductive effect of the earth's field and the mutual inductive effect of the magnets. This correction is calculated by the author. The bifilar magnetometer is, on the other hand, quite free from this error. But it is subject to a correction for the buoyancy due to the air displaced by the magnet; and this will obviously render H_b less than that calculated by the above formula. The author finds that on applying all these corrections the discrepancy between the values obtained with the two instruments is reduced to a much smaller amount. A. H.

1038. *Annual Magnetic Variation.* **G. Schwalbe.** (Berlin Phys. Gesell. Verh. 17. pp. 138–140, 1898.)—The daily magnetic period is due to currents circulating above the surface of the earth. The laws of such periods may be easily determined by plotting the successive values and directions of the horizontal magnetic force in a vector diagram. Such vector diagrams should be oriented in the astronomical, and not in the magnetic meridian. The periodic variations are then indicated by closed curves. The yearly period is the residue of the annual variation remaining after eliminating the divisional and the secular variations. If X is the component of H directed towards the north, Y that directed towards the east, and δ the westerly declination, we have

$$X = H \cos \delta, \qquad -Y = H \sin \delta$$

and by differentiation

$$dX = \cos \delta \, dH - H \sin \delta \, d\delta$$
$$dY = -\sin \delta \, dH - H \cos \delta \, d\delta,$$

so that the variations of X and Y may be found from those of H and δ. On calculating the annual period for several points on the earth's surface, it is found that in the northern hemisphere the westerly declination and the horizontal force, as well as X and Y, have a maximum in summer and a minimum in winter, while the reverse applies to the vertical force. In the southern hemisphere the reverse holds good. This permits of a conclusion with regard to the seat of the force producing the annual variation. The simultaneous increase of the westerly declination and H from winter to summer means that the north end of the magnetic needle is in summer influenced by a south pole or its equivalent, *i.e.*, an easterly current below the earth's surface, or a westerly current above it. The fact that at the same time the vertical force is weakened and the needle-point is urged upwards, shows that the current influencing it circulates in the upper atmosphere. Similar reasoning applied to the southern hemisphere leads to the same conclusion, so that both periodic disturbances are due to these currents. E. E. F.

1039. *Magnetic Inclination deduced by Magnetisation of Clay.* **G. Folgheraiter.** (Roma R. Accad. Lincei Atti, 8. pp. 121–129, and 176–183, 1899.)—For description of method see Abstract No. 839 (1899).

The civic museum of Arezzo possesses an important collection of vases made in *the first half of the century* B.C., many being authoritatively marked with the maker's name. It also contains moulds employed in the making of the vases. The inclination calculated from observations on six vases is 61° 23′; whilst the value calculated from eleven moulds is 61° 3′. The north pole dipped as at present.

The national museum of Naples contains a collection of vases excavated from Pompeii. As it is probable that cheap domestic articles were made in the neighbourhood where they were used, the author examines these rather than articles of luxury. From twenty-four cups and jars the value of the inclination is 66° 50′. From ten vases for preserving food the value is 66° 20′, differing but little from the preceding.

Various museums of Italy contain collections of Attic vases, which are generally divided into two groups: (1) those with red figures on a black ground, (2) those with black figures on a red ground. The results from these vases are not very consistent, perhaps due to some of the vases not belonging to the period imagined by the archæologists. On the whole they perhaps indicate that in certain parts of Greece the inclination was almost zero about 600 B.C., and not far from 20° about 400 B.C.

The author suggests that rebaking the vases might enable the *magnitude* of the earth's field to be determined at the time of their manufacture. A. Gs.

1040. *Boiling-Points in the Magnetic Field.* **H. du Bois.** (Berlin Phys. Gesell. Verh. 17. pp. 148–151, 1898.)—It is shown theoretically that a paramagnetic liquid undergoes in the magnetic field an increase in its boiling-point, and a diamagnetic body a diminution, the change varying with the field and the susceptibility, and inversely as the density and the heat of vaporisation. If the body is a solid capable of sublimation, like anhydrous chloride of iron, the temperature of sublimation is similarly raised. This means that the vapour pressure curves of both the solid and the liquid phases are displaced in the magnetic field. Hence also the fusing-point, determined as it is by their intersections, must be displaced. The change in the boiling point is calculated for a few liquids, exposed to a magnetic field of 50,000 c.g.s. units. For liquid oxygen it would be about $+0{\cdot}01^\circ$, for water -15 millionths, and for ethyl ether -100 millionths of a degree. The reasoning given cannot be directly applied to solutions, on account of possible changes of concentration. But for a concentrated aqueous solution of ferric chloride it must be of the order of one-thousandth of a degree, a quantity whose measurement is not hopelessly impossible. E. E. F.

1041. *Magnetism and Thermal Conductivity of Iron.* **D. Korda.** (Comptes Rendus, 128. pp. 418–420, 1899.)—The thermal conductivity of soft iron is decreased along the lines of force, and remains unaffected in directions normal to the lines. If a disc of soft iron, 320 mm. in diameter and 0·35 mm. thick, provided with a concentric circular vessel 90 mm. in diameter, be coated with a thin layer of paraffin wax, and hot water be introduced into the vessel, the wax melts along concentric circles. But if the disc be placed between the poles of a magnet, the plane of the disc being parallel to the field, the wax melts along an ellipse. The theory of this phenomenon is given, and it is shown that the effect is proportional to H^2. A. H.

1042. *Theory of Magnetism.* **H. du Bois.** (Elekt. Runds. 16. pp. 80–82, 1898.)—A brief historical sketch dealing with the development of modern magnetic theories, with special reference to the important contributions due to the late Dr. Hopkinson.

A. H.

CHEMICAL PHYSICS AND ELECTROCHEMISTRY.

1043. *Colloidal Glass.* **C. Barus.** (Amer. Journ. Sci. 6. p. 270, 1898.)—The author has succeeded in impregnating glass with water to such an extent that it becomes fusible below 200° C. The clear water-glass so obtained, if heated in a gas-burner, swells up with loss of water, and is reduced to a white porous mass. On the basis of his experiments the author announces that glass as a *colloid* is miscible with water in all proportions. Such solutions if sufficiently concentrated *coagulate* at ordinary temperatures, the congealed aqueous glass resembling ordinary glass in general appearance, and melting frequently under 200° C. F. G. D.

1044. *Thermodynamic Relations of Hydrated Glass.* **C. Barus.** (Amer. Journ. Sci. 7. pp. 1–3, 1899.)—The author studies the action of hot water on glass (200° C.). There are two stages. In the first the glass becomes opaque, and there is relatively great contraction of volume and increase of compressibility. In the second the product (water-glass) becomes more and more clear, the volume-contraction falls off asymptotically to zero, and the compressibility after reaching a maximum diminishes with great rapidity. On cooling, the product is clear, and as hard and brittle as ordinary glass. Held in a candle-flame, a small piece soon fuses with loss of water to a milk-white pumice. The author interprets the phenomena observed in the light of Gibbs' Phase Law, assuming the existence of two phases of the water-glass. F. G. D.

1045. *Aqueous Fusion of Glass.* **C. Barus.** (Phil. Mag. 47. pp. 104–109, 1899.)—The results of experiments on the action of water at 185° C. on glass are given. The water was kept liquid by pressure. These results are stated in the subjoined table. The water was contained in sealed capillary glass tubes, and while it increased in compressibility it steadily diminished in bulk; the thread was contained within the walls of the tube between two terminal threads of mercury, and the decrease of the length of the thread of water which occurred indicated contraction of volume of the system of glass and water in contact. In the table, θ denotes the temperature of the capillary thread; t, the time of the observation, counting from the beginning of ebullition in the vapour-bath used to keep the temperature constant; v, the total increment of volume due to the thermal expansion; V, the total volume, so that v/V is the mean expansion per unit volume at 185°; β, the mean compressibility within 300 atmospheres.

Table showing Thermal Expansion and Compressibility of Silicated Water at 185° and 20 to 300 atmos. Diameter of tube 0·045 cm. Length of column of water at 24°, 14 cm.

θ	$v/V \cdot 10^3$.	$\beta \cdot 10^6$.	t
24 °C.	±0	44	
185	+103	77	18 min.
185	86	97	25
185	75	112	30
185	60	125	35
185	+44	141	40
185	+27	163	45
185	+05	184	50
185	−15	221	55
185	−29		60

At the conclusion of the experiment the thread seemed to be solid at high pressure (300 atmos.), though not apparently so at low pressure. Examining the values of v/V given in the table, it appears that whereas the original volume increment per unit of volume is greater than 0·103 for the rise of temperature from 24° to 185° at 20 atmos., this increment has nearly vanished after 50 minutes of reaction. The thread at 185° is now only as long as it was at 24°. After 60 minutes of reaction it is even markedly shorter at 185° than at 24°, pressure remaining constant throughout. At the same time the compressibility, β, of the silicated water at 185° is found to increase regularly from 0·000077 near the beginning of the experiment, to over 0·000221, or more than three times its initial value on the same isothermal (185°). This result is remarkable and unexpected, since without exception the effect of solution is a decrease of the compressibility of the solvent, in proportion as more substance is dissolved. Silicated water in the present experiment shows the reverse. Correlative experiments were made with saturated solutions of zinc sulphate in water, and naphthalene in alcohol. In both cases markedly increased compressibilities were possible in a turbid column, due to the precipitation of part of the dissolved salt, isothermally, by pressure. During compression a part of the dissolved body is changed from the liquid to the solid state by pressure, and hence the apparent increase of compressibility. The reaction of the water on the glass must be along the surface of contact, and the length of the column of water will decrease faster for small values of the capillary radius. In the experiment described the volume of water absorbed per sq. cm. of surface of contact corresponds to about 180 kg. per sq. metre per year at 185°. These experiments have an important bearing on the behaviour of water in finely porous rocks. The pressure and temperatures in the experiments made would be more than reached by a column of water penetrating a few miles below the earth's surface. The action of hot water on rock within the earth seems to constitute a furnace whose efficiency increases in a marked degree with the depth of the seat of reaction below sea-level. J. J. S.

1046. *Gases Occluded by Moist Glass.* **F. Mehlhorn.** (Berlin Phys. Gesell. Verh. 17. pp. 123–128, 1898.)—The author investigates the absorption of atmospheric air by the thin coating of moisture which, according to Bunsen's researches, adheres to glass until it is brought to a temperature of 500°. He finds that 80 or even 90 per cent. of the gas thus absorbed consists of carbonic acid. This explains to some extent the persistent occurrence of the spectrum bands of CO in the sparking spectra, since CO is generated by sparking CO_2. E. E. F.

1047. *Process of Crystallisation.* **A. Heydweiller.** (Wied. Annalen, 66. 5. pp. 1194–1195, 1898.)—The author replies to Tammann's criticism (see 1899, Abstract No. 326) of his discovery of a continuous transition between solid and liquid menthol, apparent continuity being ascribed to impurities in the menthol used. The author maintains that the phenomena observed are the same in specimens of menthol purified by repeated freezing. In the experimental arrangement used, the menthol must in fact purify itself. The author also fails to conceive how the solution of foreign substances in the liquid menthol could lead to the disappearance of the meniscus separating the solid and liquid phases. E. E. F.

1048. *Reaction Velocity in Aqueous Alcohol.* **W. Kistiakowsky.** (Zeitschr. Phys. Chem. 27. pp. 250–266, 1898.)—The equation of the progress of reaction is confirmed, and the same constants found by decomposition as by formation of etherial salts in presence of HCl: the autocatalysis without HCl is also investigated. The former are first retarded somewhat and then considerably accelerated by increasing the strength of alcohol; the latter are always retarded. The chloracetic acids form a transition in behaviour from organic to inorganic acids. Acetic acid gives smaller constants than formic, chloracetic than acetic, as the difference in ionisation predicts. B. B. T.

1049. *Electrosynthesis.* **W. G. Mixter.** (Amer. Journ. Sci. 6. pp. 217–224, 1898.)—Gases under various conditions of pressure and mixture are enclosed in endiometers connected in parallel. The heat resulting from the combination effected by the feeble glow discharge does not cause further combination, as is shown by the fact that when the discharge is concentrated in a small space there is no increase in the proportion of hydrogen and oxygen combined. The higher the pressure the more rapid is the combination, but no simple relation can be traced between them.

A mixture of 23·6 cc. of oxygen and 28·8 cc. of ammonia contracted by 23·9 cc., five-sixths of the nitrogen supplied being thus absorbed, while the remainder entered into a non-gaseous compound. This was ammonium nitrite, which formed a white coating on the sides of the endiometer, and which reacted for nitrous acid with the usual tests. The products obtained with a mixture of cyanogen and oxygen are very complicated, but it is certain that cyanogen is oxidised more rapidly than hydrogen. The following table gives a summary of the probable changes, one vol. of hydrogen and oyygen being supposed to contain 100 molecules :—

Gases used.	Molecules reacting.	Molecules oxidised.		Molecules of Oxygen consumed.
Hydrogen and oxygen ...	100	H_2	67	33
Ammonia „ ...	168	NH_3	88	72
„ „ ...	179	„	89	77
Methylamine „ ...		NH_2CH_3	46 to 70	
Dimethylamine „ ...		$NH(CH_3)_2$	57 to 70	
Trimethylamine „ ...	265	$N(CH_3)_3$	42	213
Hydrogen and nitrous oxide	112	H_2	56	
„ nitric „		Little if any hydrogen oxidised.		
Carbonic oxide and nitric oxide.		Some carbonic oxide oxidised.		

E. E. F.

1050. *Chemical Actions of Electric Brush Discharge.* **Berthelot.** (Annal. Chim. Phys. 16. pp. 5–80, 1899.)—The author has made a long series of further experiments concerning the action of the *effluve électrique*, more especially with regard to the fixation of nitrogen by organic compounds. The bodies dealt with contain only the four elements oxygen, nitrogen, hydrogen, and carbon, so as to limit the field of investigation. The author maintains that the results obtained open up a very wide and fruitful field of research, equal in importance to pyro-chemistry. The bodies exposed to the action are placed either singly or in a mixed state into a narrow space between armatures, where they act as dielectrics, and are subjected to a noiseless and invisible discharge from a rapidly interrupted induction coil of 12 mm. spark-length. The duration of each experiment is 24 hours, but intermediate products are also examined. The usual form of apparatus employed consists of two concentric glass tubes with a cylindrical space 1 mm. thick between them. Various pressures and various temperatures are employed. Most of the experiments quoted deal with gaseous bodies; but there are also a few on liquids and solids. Essence of terebenthene is slightly polymerised in 24 hours. So is olive oil. Alcohol gives off some hydrogen and ethane, and about 1 per cent. is converted into aldehyde. The action observed in general consists of two distinct parts: a decomposition giving rise to the separation of hydrogen and the simplest binary compounds, and a condensation or polymerisation leading to the formation of complex substances of a high order. The author points out the analogy to what happens to food taken into the animal body.

Carbonic oxide and anhydride, acted upon in the presence of an excess of hydrogen, produce carbo-hydrates, the general formula being

$$\left.\begin{array}{l} n\,(\mathrm{CO}+\mathrm{H_2}) \\ n\,(\mathrm{CO_2}+2\mathrm{H_2}) \end{array}\right\} = \mathrm{C}_n\mathrm{H}_{2n}\mathrm{O}_n - m\mathrm{H_2O}$$

With deficiency of hydrogen, more highly oxidised compounds are obtained. The presence of nitrogen leads to the formation of richly nitrogenised compounds of the uric or xanthinic type. When water is formed, ammonium nitrite is formed as well.

The carbides of the acetylene series are changed into condensed polymers, without notable loss of hydrogen. The ethylene series is also polymerised, loses hydrogen, and approaches the camphene series. The formenes are converted into ethylenes. All the carbides fix nitrogen and form alkaline compounds of the polyamine type, probably cyclical. Some of the transformations are only suggested by the empirical formulæ. It is just as likely that new and hitherto unknown compounds are formed.

All the alcohols studied absorb nitrogen when present in the gaseous state, forming amidines and related bodies. This fixation is, in the case of the fatty alcohols, accompanied by a loss of hydrogen. The aldehydes and the organic acids also fix nitrogen under the influence of the silent discharge. In the case of the acids, there is practically no loss of hydrogen, the presence of the oxygen tending to maintain it fixed in the molecule, usually as water. One molecule of acid fixes about an atom and a half of nitrogen, at least in acetic and propionic acids. E. E. F.

1051. *Equation for Reversible Reactions.* **J. Waddell.** (Journ. Phys. Chem. 3. pp. 41–45, 1899.)—Walker and Hambly's simplified equation for a monomolecular reversible reaction (Journ. Chem. Soc. 67. p. 753, 1895) is shown to be mathematically valid, but not that for a bimolecular reaction. Instead of $dx/dt=k\,(x-\xi)^2$ the author finds $dx/dt=k_1\,(1-a)\,(x-\xi_1)\,(x-\xi_2)$ where $a=k_2/k_1$ and ξ_1 and ξ_2 are the roots of $k_2/k_1=(A-\xi)^2/\xi^2$ namely, $\xi=A/(1\pm\sqrt{a})$. Here $\xi_2(=A/\{1+\sqrt{a}\})$ is the actua

value of x at the equilibrium point, ξ_1 is the impossible value for the same. Integration gives a constant, the values of which are calculated; the agreement is worse than the old equation showed.
B. B. T.

1052. *Theory of Residual Current.* **E. Salomon.** (Zeitschr. Phys. Chem. 25. pp. 365–371, 1898.)—The author states that his theory of the residual current with polarised electrodes (Zeitschr. Phys. Chem. 24. p. 55, 1897) was false in principle, and gives the correct theory of Jahn; the calculated values are, however, about fifteen times smaller than the observed, while the old formula gives empirically a rough coincidence. B. B. T.

1053. *Boiling-Points of Mixed Solutions.* **T. W. Richards** and **W. L. Harrington.** (Zeitschr. Phys. Chem. 27. pp. 421–425, 1898.)—A liquid containing several salts in solution boils at a lower temperature than that calculated by adding together the depressions of the boiling-point due to each salt by itself; this behaviour is due, at least in part, to the formation of double salts which lower the osmotic pressure. It may, however, be partly due to the dissociation of one salt being affected by the presence of another. To investigate this point the authors propose to choose such mixtures as show a tolerable alteration of B.P. and are little likely to form double salts. Such are cadmium oxalate in dilute hydrochloric acid, in which the maximum B.P. occurs with a 25 per cent. strength of the acid. With these, the mean of four experiments gave 0·101° as the lowering of B.P. by 1 gram-molecule of CdC_2O_4 in 10 litres of water containing a slight excess of HCl, while the theoretical rise of B.P. due to addition of 1 gm.-mol. to the same mass of water is 0·052°; the mixture thus seeming to result in a diminution of the number of gm.-mols. by 2, while the theoretical reaction gives a reduction of 3. Molecular combinations therefore appear to accompany the reaction. The replacement of the oxalate by the citrate alters the lowering of B.P. to 0·434°, so that 8 active molecules seem to be removed, theory giving 7. R. E. B.

1054. *Boiling-Points of Mixed Solutions.* **C. McC. Gordon, L. J. Henderson,** and **W. L. Harrington.** (Zeitschr. Phys. Chem. 27. pp. 425–428, 1898.)—The authors investigated the effect of adding $CdSO_4$ to solutions of NaCl, in which the action is much more complicated than that in the previous Abstract, from the greater abundance of double salts that may be formed, and their results show that theoretical calculation is useless without exact knowledge of these ever-varying reactions. They found the lowering of B.P. with continuous addition of $CdSO_4$ to increase to a maximum and then to fall off, the hitherto unknown case of the addition of a solid raising the vapour pressure of a solution being thus exhibited. R. E. B.

1055. *Freezing- and Boiling-Points.* **A. Battelli** and **A. Stefanini.** (N. Cimento, 9. pp. 5–66, 1899.)—As a result of a very elaborate and painstaking research, the authors arrive at the conclusion that the molecular depression of the freezing-point remains practically constant as the dilution increases, and that for very dilute solutions it has a value not differing much from 1·87. This means that Raoult's straight line is confirmed, and the curve found by the majority of other investigators is disproved. A few experiments were also made to determine the boiling-point of tartar-emetic solution, and it was found that the molecular weight thus deduced did not sensibly alter with the dilution. E. E. F.

1056. *Solubility, Ionisation, and Heat of Solution.* **H. Goldschmidt.** (**G. v. Maarseveen.**) (Zeitschr. Phys. Chem. 25. pp. 91–99, 1898.)—The solubility and ionisation of $AgC_2H_3O_2$, $AgC_3H_5O_2$, $AgC_4H_7O_2$ (iso), and o-nitrobenzoic acid were determined and the heat of solution calculated by van't Hoff's formula $\frac{d \log S}{d T} = \frac{q}{2 i T^2}$ (S is solubility), and van Laar's formula $\frac{d \log S}{d T} = \frac{q (2-a)}{4 T^2}$ compared with that directly observed. The last lies, in the case of the highly ionised silver salts, between the two calculated values, while the weakly ionised acid, which obeys Ostwald's law of dilution, agrees with the latter formula, which premises such obedience. B. B. T.

1057. *Ionisation in Stages of Dibasic Organic Acids.* **W. A. Smith.** (Zeitschr. Phys. Chem. 25. pp. 144–177 and 193–264, 1898.)—The author determines the ionisation-constant of the first H atom of 26 dibasic organic acids from the conductivity, and that of the second H atom, in the acid sodium salts of the same and 35 others, by the velocity of sugar inversion at 100° in various concentrations (Trevor, Zeitchr. Phys. Chem. 10. p. 321, 1892); one tribasic acid (citric) is included. The reliability of the method is investigated, and the reduction factor (inversion-constant/conductivity) found to vary from 13 to 16½ with the acid and concentration, the latter influence vanishing when the ionisation is complete. Water alone inverts considerably and irregularly, as also neutral salts, but this action is restrained by the presence of acids. The accelerating influence of salts on acids seems to be proportional to the ionising tendency of the acid they contain, rather than their actual ionisation. The time correction is better avoided by calculating from the inversion observed after the first time interval. Ostwald's dilution formula holds for the acids, while for the acid salts the concentration of H is constant, as Trevor found and Noyes (Zeitschr. Phys. Chem. 11. p. 495, 1893) proved theoretically. In the homologous series investigated (oxalic, substituted malonic and succinic, phthalic, maleic and fumaric, camphoric, &c.) Ostwald's rule that the first H atom is weaker and the second stronger, the nearer the acid groups are to one another, is confirmed; the second is always found to be weakened by the entrance of substituting groups except hydroxyl; and lastly, in substituted acids (alkylmalonic and succinic acids) the second atom is weaker, the stronger the first (contrary to Noyes' rule). B. B. T.

1058. *Validity of the Calculation of Ionisation from Conductivity.* **H. Jahn.** (Zeitschr. Phys. Chem. 27. pp. 354–356, 1898.)—The author points out that in deducing $\alpha = \frac{\lambda}{\lambda_\infty}$ from $\lambda = \alpha\ (u+v)$ the assumption is made that u and v are independent of the concentration. This is probable for weakly ionised compounds, and hence also Ostwald's dilution formula $\frac{(\lambda/\lambda_\infty)^2}{V(1-\lambda/\lambda_\infty)} = K$. As this does not hold for strong electrolytes, while the validity of the law of mass action requires that $\frac{C^2}{C_1} = k$ (where C and C_1 are the concentrations of ion and undissociated compound, and equal to α/V and $(1-\alpha)/V$), and therefore $\frac{\alpha 2}{V(1-\alpha)}$ = constant, the author concludes that $u+v \neq u_\infty + v_\infty$ and hence $\alpha \neq \lambda/\lambda_\infty$. Measurements like those of Hopfgartner and Hoffmeister give uC direct. The author states preliminarily that he finds $uC\sqrt{V}$ constant "in every electrolyte."

[This is presumably a misprint for $C\sqrt{V}$ = constant: $uC\sqrt{V}$ = constant would imply by analogy $vC\sqrt{V}$ = constant, whence $(u+v)C\sqrt{V} \equiv \lambda\sqrt{V}/V = \lambda/\sqrt{V} \equiv$ constant, which is *not* the case.] B. B. T.

1059. *Conduction in Mixed Electrolytes.* **K. Hopfgartner.** (Zeitschr. Phys. Chem. 25. pp. 115–143, 1898.)—Author extends work of Schrader (Zeitsch. f. Elektrochem. 3. 498) to mixtures of HCl with NaCl and $BaCl_2$ and $CuSO_4$ with $MgSO_4$ in N and N/5 solutions. The amounts of each kation transported in a mixture are determined by analysis: the ratio of these should be, according to Planck's theory (Wied. Ann. 39. 161), proportional to that of the concentrations × the respective mobilities. Assuming the latter equal to their values in dilute solutions, the former are calculated and found to compare (within 3 to 25 per cent.) with those deduced from conductivity measurements of equally concentrated solutions of each salt alone. Hence the ionisations of these salts are not (greatly) changed by mixture.

The transference values of HCl, NaCl, and $BaCl_2$ are also determined for various concentrations from N/10 to 9N/10 and a slight fall found for the first and a decided rise (0·35–0·38 and 0·38–0·42) for the latter two. From these are calculated the total amounts of kation liberated and an agreement found to within 3 or 4 per cent. with the measurements of a silver voltameter: the sulphates differ more (10–20 per cent.). B. B. T.

1060. *Conduction in Mixed Electrolytes.* **H. Hoffmeister.** (Zeitschr. Phys. Chem. 27. pp. 345–353, 1898.)—The author investigates mixtures of $AgNO_3$ with HNO_3 and $NaC_2H_3O_2$ with $C_2H_4O_2$, in the same way as Hopfgartner (see preceding Abstract); the concentration of the Ag and Na ions is calculated and found to agree with that for the same concentration of pure substance when the admixture is not in excess, in which case it is reduced, as theory predicts. B. B. T.

1061. *Fluidity and Electrolytic Conductivity.* **R. Dennhardt.** (Wied. Annalen, 67. 2. pp. 325–344, 1899.)—The attempt to trace a close relation between fluidity and conductivity fails in the more concentrated solutions. Oleic acid and oleates have peculiar properties. The maxima of molecular conductivity in their alcoholic solutions correspond to minima of temperature coefficient. E. E. F

1062. *Electrolytic Formation of Alkali-Amalgams.* **A. Schoeller.** (Zeitschr. Elektrochem. 5. pp. 259–261, 1898.)—The attempt to establish equilibrium between electrolytic polarisation of mercury electrodes in solutions of alkalies (NaOH and $Ba(OH)_2$) and concentration of the amalgam formed, fails in consequence of re-solution causing a residual current. The E.M.F. of amalgams so formed was observed and found to agree with that calculated from the concentration by Nernst's formula. B. B. T.

1063. *Electrolysis of Water.* **D. Tommasi.** (Elect. Rev. 44. pp. 293–295, 1899.)—In order to account for the electrolysis of water on the application of an E.M.F. much lower than that corresponding to its heat of formation, the author suggests that water at any temperature contains a certain amount of uncombined oxygen and hydrogen, these uncombined molecules exercising, nevertheless, a certain attraction upon each other. This idea is supported by the work of Deville upon the decomposition of water by heat. The electrolytic separation of these uncombined molecules the author terms *pseudo-electrolysis.*

[This suggested dissociation is apparently quite distinct from ionisation.] W. R. C.

1064. *Chemical Properties of Aluminium.* **A. Ditte.** (Comptes Rendus, 128. pp. 195–201, 1899.)—In a former paper (see 1899, Abstract No. 847) the author showed that aluminium is dissolved by a solution of common salt, provided some weak acid is present. In this paper the oxygen abstracted by the solution from the air is shown to materially hasten the action, especially near the surface of the liquid. When no acid is introduced into the solution, the carbonic acid which the liquid abstracts from the air can fulfil its purpose, and hence it is that aluminium is slowly dissolved in salt water exposed to the air. The action in the case of sea water containing, besides common salt, other chlorides and also bromides is considered. J. B. H.

1065. *Progress of Aluminium.* (Engineer, 87. pp. 155–156, 1899.)—This article describes the advance made in the extraction and treatment of aluminium during the last two years, and *inter alia* refers at length to Wallace's paper before the Soc. Chem. Ind. (see 1898, Abstract No. 961). The yield of aluminium by the Héroult process is now 1 lb. per 12 E.H.P. hours, with a pressure of 3 to 5 volts and a bath-temperature of 750°–850° C. Accepting Thomson's figure for the atomic weight of Al (26·77 when $H=1$) and the theoretical voltage of the Héroult cell as 2·4 (obtained by deducting 0·65 volt, the electrical equivalent of the heat of formation of carbon monoxide, from 3·05 volts, the theoretical E.M.F. of liquid alumina), the theoretical output of Al per E.H.P. day of 24 hours is 5·487 lb. Taking the mean (4) of Wallace's voltages, the energy efficiency of the process is 36·45 per cent. and the current efficiency is 60·07 per cent. Two or three years ago these numbers were 22·7 and 40·6 per cent. respectively.

The proposal made in 1892 by Chatterton for the application of power obtainable from the Periyar Irrigation Works (in India) to the production of aluminium has not yet been taken up. But, meanwhile, Chatterton, by teaching the methods of working the metal in the Madras College of Engineering, is accustoming the natives of Southern India to the use of aluminium, and so preparing a demand which in time may lead to the establishment locally of a new electric smelting industry. Hunt (see 1898, Abstract No. 437), has claimed that with aluminium at 29 cents per lb. it can compete with copper for conductivity purposes, and with wire for a given current would show for the same cost a gain of 52 per cent. in weight and of 60 per cent. in strength, with an increase of 26 per cent. in diameter. He reckoned the conductivity at 63 (Cu = 100). Kershaw (see 1899, Abstract No. 164), taking the conductivity at 59, and with certain other data, finds the Al to be 1⅓ times as costly as Cu. Accepting Lord Kelvin's latest determination of conductivity (60·5 for 99·7 per cent. Al), the true electrical capability of the metal would lie between Hunt's and Kershaw's figures. Russell estimates an increase of 10 to 15 per cent. in cost against aluminium. But the two metals can only come into competition for bare wires, as the comparatively great diameter of Al conductors necessary for a given current capacity militates against the economical use of this metal for insulated wires. Nevertheless aluminium has been used for telephone work, and at Foyers and Pittsburgh and in Germany it has been employed for heavy currents apparently with success. It is also to be used to conduct a 30,000 volt current from the generating station of the Snoqualmie Falls Power Co. to Seattle and Tacoma, 20 miles distant. The principal use for aluminium is in the iron and steel foundry, where it is very commonly added in small quantities to the metal immediately before casting. The next largest field is in the manufacture of cooking utensils. Opinions differ as to the utility of aluminium for shipbuilding. As Ristori has shown, a part of the prejudice against it is traceable to the early use of an alloy of Al with 6 per cent. Cu, which, naturally, was rapidly corroded in salt water. Nevertheless the metal has been unduly corroded, even where not in contact with more electro-negative metals, on the sheathing of the yacht *Defender;* and the cause of this has not yet been explained. The Spanish-American war has demonstrated the value of the metal as a substitute for inflammable wood in warships. The soldering of aluminium is inevitably a trouble, as all the solders of sufficiently low fusing-point are electro-negative to the metal. Autogenous soldering, however, does not suffer from this defect. The metal is now being extensively used in place of lithographic stones. W. G. M.

1066. *Electrolytic Manufacture of Sodium and Potassium.* (Indus. and Iron, 26. p. 206, 1899.)—This is a description of an apparatus intended for the production of sodium, or potassium, lead alloys by the electrolysis of their halogen salts in the fused state. The anode compartment is separated from the kathode by a species of inverted bell, magnesia being employed as lining. A device for the circulation of the lead-sodium alloy is provided in order to ensure the absorption of the liberated sodium by the lead. The apparatus is explained by means of a drawing. O. J. S.

GENERAL ELECTRICAL ENGINEERING.

1067. *Primary Batteries.* **E. Petersen.** (Zeitschr. Elektrochem. 5. pp. 261–265, 1898.)—When $ZnSO_4$ is replaced by NaCl (1 in 4) in a Bunsen cell, the E.M.F. is raised 0·073 volt, and the resistance is the same as with H_2SO_4. The HNO_3 may be replaced, without serious loss of E.M.F. by $K_2Mn_2O_8$ (1 in 16), giving 1,678 volts; by 1 per cent. H_2O_2 with dilute H_2SO_4, 1,699 volts; by PbO_2 in dilute H_2SO_4, 1,991 volts; or by NaOCl (without free Cl_2), 2,021 volts; but these cells are inferior in constancy. The cell

Zn | NaCl (1 in 5) | $FeCl_3$ 6 aq. (2 in 1) | carbon

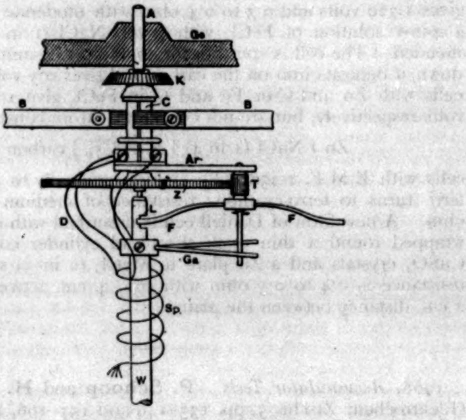
gives 1,720 volts and 0·3 to 0·4 ohm with moderate dimensions: a 4-in-1 solution of $FeCl_3$ with ¼ vol. NaCl (1 in 4) is recommended. The cell is constant for hours up to 1 amp.; when run down, it deposits iron on the carbon and gives 0·5 volt. One-fluid cells with Zn and C or Fe and C in $FeCl_3$ give 1·60 and 0·90 volts respectively, but are not constant. More constant are

Zn | NaCl (1 in 4) | K_3FeCy_6 | carbon

cells with E.M.F. 1·438 volts, sinking gradually to 1·105 as the ferri- turns to ferro-cyanide; resistance of medium size cells ¼ ohm. A new form of Daniell cell is described with copper gauze wrapped round a thin open sheet-lead cylinder containing the $CuSO_4$ crystals and a Zn plate in $MgCl_2$ (2 in 5) solution: the resistance is 0·4 to 0·5 ohm with 400 sq. cm. active surface and 2 cm. distance between the plates. B. B. T.

1068. *Accumulator Tests.* **P. Schoop** and **H. Benndorf.** (Elektrochem. Ztschr. 5. pp. 133–149 and 157–166, 1898.)—The paper contains a detailed account of tests carried out on 3 different types of secondary cells. It is pointed out that the relative merits of various types of cells cannot be arrived at from an investigation of their behaviour during a test, unless the particular purpose for which the accumulator is required is known. In the tests described an auxiliary electrode of cadmium was used, and the following quantities were observed, in the order given: (1) P.D. between cadmium and spongy-lead electrodes with current passing through cell; (2) also on open circuit; (3) P.D. between peroxide and cadmium electrodes when current was flowing through cell; (4) also on open circuit; (5) P.D. between terminals of cell; (6) E.M.F. of cell. All these results are tabulated, and plotted in the form of curves. A comparison of the cells as regards capacity, &c., is obtained by determining the capacity per kilogram-weight of cell in each case. The authors particularly insist on the advantage of using an auxiliary cadmium electrode, as by means of it it is possible to determine which of the two plates gets exhausted sooner; such information may lead the manufacturers to considerable improvements in the construction of the cell. A. H.

1069. *Hiecke Electric Meter.* (Electrician, 42. p. 581, 1899.)—In this meter the motion of a hollow shaft or sleeve driven by clockwork and geared with the counting train through the bevel wheel, K, is controlled by an electric motor having its armature-shaft, W, concentric with the sleeve. The sleeve bears the commutator, C, and an arm, A*r*; at the end of A*r* is an arbor on which there is a pinion, T, gearing with a stationary concentric gear-wheel, Z, and also two arms, FF. These arms are adapted to pass through a lateral slot, L, in the armature-shaft, W, at one point in the revolution of the shaft, thus enabling them to make a half-revolution corresponding to $\frac{1}{20}$-revolution of the sleeve and arm A*r*; the shaft W then moves $\frac{1}{20}$-revolution. Thus the shaft W and the arm A*r* each move through $\frac{1}{20}$-revolution alternately, the motion of the shaft W being limited by arms, G*a*, acting on the end of the pinion shaft. By these means the rotation of the armature shaft W is rendered independent of the friction of the brushes B on the commutator C. C. K. F.



1070. *G. E. Regulator for Series Arc-Lighters.* (Elect. Rev. N.Y. 34. p. 28, 1899.)—The regulator consists of (1) a rotary oil pump driven by a belt from the armature shaft, and delivering oil to the valve chamber of (2) a cylinder with a radial partition and a rotary piston; (3) an electromagnet placed in the main circuit and controlling, by its action on an armature, a balanced valve which admits oil into the cylinder on one side or the other (or both) of the rotary piston, thus causing it to move one way or the other (or to remain stationary); (4) a field rheostat forming a shunt across the field, with a number of contacts, over which moves an arm mounted on the axle of the rotary piston; (5) a toothed segment, supported by an arm projecting from the brush rocker, and gearing into a pinion also mounted on the axle of the piston. In maintaining constant current, the regulator performs two functions: it varies the resistance of the field shunt, and rocks the brushes one way or the other, so as to keep the spark-length at a minimum. This regulator is intended for use with 4-pole Brush arc-lighters, and is made by the General Electric Company. It is contained in a rectangular case placed directly beneath the commutator. A. H.

1071. *Alioth Alternate-current Radiators.* **R. B. Ritter.** (Électricien, 17. pp. 33–35, 1899.)—In these radiators, which are made by the Société d'Électricité Alioth, of Basle, the heat is generated in the object to be heated itself by means of Foucault currents. For this purpose solid plates of iron are subjected to an alternating magnetic field from bobbins traversed by the alternating current, copper rings being also embedded in these plates to promote this action. Various forms of heater constructed on this principle are described and illustrated. C. K. F.

1072. *Electric Light Switchboards.* **S. H. Sharpstein.** (Amer. Electn. 11. pp. 29–30, 1899.)—The author recommends automatic cut-outs, small marble panels, and easily removable apparatus; he also discusses separate exciter boards and 'bus bars. M.O'G.

1073. *Mnemonic for Conductor Resistance on Three-Wire System.* **W. H. Donner.** (Amer. Electn. 11. pp. 27–28, 1899.)

$$\text{Resistance in ohms per foot} = \left\{ \frac{\text{Twice the allowable drop of volts.}}{(\text{the number of lamps}) \times (\text{the distance in feet.})} \right.$$

A middle wire equal to the outer is recommended. M. O'G.

1074. *Electrolysis by Stray Currents.* **A. A. Knudson.** (Elect. Engin. N.Y. 27. pp. 228–230, 1899.)—Report to the Water Commissioners of Jersey City on the electrolysis of their water-mains. Excavations were made in two places, and the rails were found to be positive to the pipes by 10 volts and 15 volts respectively. From maps it was concluded that this current would probably quit the pipes in a certain salt marsh, and take a short cut to the power station. Tests confirmed this. Of three parallel pipes traversing the marsh, the two outer ones were positive to the marsh by ½ volt, and the inner one negative by 1 volt. In the presence of salt water this difference of potential will materially corrode the pipes. E. H. C.-H.

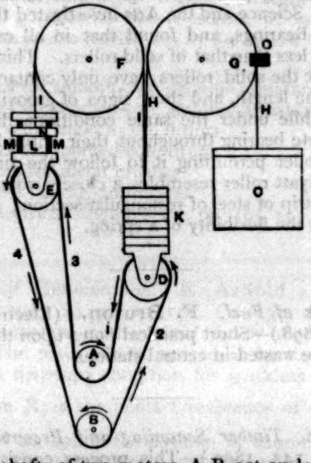
1075. *Prevention of Collisions at Sea.* **G. Dary.** (Électricien, 17. pp. 17–19, 1899.)—An invention by H. Herbert is described, in which two or more thermopiles are mounted on a vertical shaft capable of rotation; they are shielded so as to exclude all air currents, and all radiations, from the ship and from solar rays, whether direct or reflected from the surface of the water. The thermopiles are supposed to receive radiation from any approaching ship, and actuate relays of the d'Arsonval galvanometer type, ringing a bell when pointing in the direction of the approaching object. E. C. R.

1076. *Electrical Apparatus on U.S. Battleships.* **F. W. Roller.** (Elect. Rev. N.Y. 34. p. 13, 1899. Paper read before the New York Electrical Society, November 14, 1898.)—In this paper the performance of the various types of electrical apparatus used on shipboard in the recent war is discussed. It was found that indicating apparatus of the galvanometer type was not satisfactory. The electric firing device for rapid-fire guns worked very well on the *Nashville*. Signalling was carried on by means of the "Ardois" apparatus, which consists of a string of four lanterns, each half clear glass and half red; inside each were two lamps, either of which could be illuminated independently, the different signal-combinations being obtained by means of a keyboard. The search-lights, motors for ammunition hoists, turret training, ventilating, fan driving, and steering gear worked well.

C. K. F.

1077. *Economic Test of a Boiler Feed-Pump.* **F. M. Wheeler.** (Mech. Eng. 2. pp. 873–874, 1898.)—It has been shown that the steam consumption of a duplex feed-pump will average about 120 lb. per I.H.P. hour, while in the U.S.A. battleship *Minneapolis*, some pumps consumed over 200 lb. of steam per I.H.P. per hour. The pump referred to in the paper consumed 52 lb. of steam per I.H.P. hour; the test was conducted by Messrs. Willans and Robinson, Rugby, and was for the benefit of the British Admiralty. The pump is a cross compound one; the valve gear is such that the low-pressure cylinder may be shut off, and the high-pressure side may act as a simple pump. The valve gear is fully described in the paper. As regards economy, this particular pair of pumps with attachments weigh about half a ton, and handle about 17,570 lb. of feed water per hour. The power of the pump, working compound, was 5·6 I.H.P. On the basis of a saving of 70 lb. weight of steam per I.H.P. per hour over and above what would be used in a duplex pump, a total saving of steam of about 393 lb. per hour, or about 50 lb. of coal per hour is effected. This gives a total saving of 1,200 lb. of coal per twenty-four hours. A. S.

1078. *Electric Elevators.* **A. E. B. Ridley.** (Mech. Eng. 3. pp. 58–60, 1899.)—In this article, the Sprague-Pratt and Ward-Leonard elevators are briefly described, together with one designed by E. M. Fraser, wherein all gearing has been eliminated and the motors are never reversed, the brake being used only for braking the car. In this elevator, of which a diagram is given, pulleys on the shafts of two motors, A B, act on loops on an endless rope, 1, 2, 3, 4, whilst in other loops are idler pulleys, E D, attached to an adjustable frame L, and a counterweight, K, respectively, and both movable vertically in guides. C is the car and O a brake clutch. If A rotates faster than B, D moves down and the car C up; whilst if B rotates faster than A, D moves up and the car C down. By varying the speeds of A and B, the car can be made to move up or down or to stop as desired. C. K. F.



1079. *Efficiency of Electric Pumps.* (Elect. Rev. N.Y. 33. p. 380, 1898.)—A test was made on a Worthington horizontal triple pump driven through spur gearing by two 65 H.P. alternating current motors. The speeds of motor and pump respectively were 450 and 45 revolutions per minute. The tests were made at constant speed and variable loads, and were under the supervision of disinterested engineers. Curves are plotted from the observed data; the combined efficiency from switchboard to the water column is nearly 70 per cent. at the greatest load; which is thought to be remarkably good, considering that the water end of the pump had six plungers, and that the pump had just come from the shop. A. S.

1080. *Hyatt Roller Bearing.* (Frank. Instit. Journ. 147. pp. 145–150, 1898.)—The Franklin Institute recommends the award to John W. Hyatt of the John Scott Legacy Premium and Medal, for his invention of the elastic spiral anti-friction roller. The Committee on Science and the Arts investigated the merits of the Hyatt Roller Bearings, and found that in all cases the rolling resistance was less than that of solid rollers. This they attributed to the fact that the solid rollers have only contact at one or two points along the length, and show signs of grooving at the points of contact; while under the same conditions the spiral rollers show a complete bearing throughout their entire length, the elasticity of the roller permitting it to follow the sinuosities of the plate. The Hyatt roller resembles a closely wound spiral spring, made from a strip of steel of rectangular section: the roller consequently has all the flexibility of a spring. A. S.

1081. *Waste of Fuel.* **F. Bruton.** (Electricity, N.Y. 15. pp. 310–311, 1898.)—Short practical notes upon the way in which fuel is apt to be wasted in central stations. W. R. C.

1082. *Electric Timber Seasoning and Preservation.* (Elect. Engin. 23. p. 143, 1899.)—This process consists in forcing a solution of 10 per cent. of borax, 5 per cent. of resin, and 5 per cent. of carbonate of soda, heated by a steam coil, through wood by means of a current of about 600 amperes at 110 volts, by electric endosmose for from five to eight hours, and then drying at a temperature of 75°. The current required is 18 amperes per cubic foot. The inventors are Nodon and Bretonneau. C. K. F.

GENERATORS, MOTORS, AND TRANSFORMERS.

1083. *Limit of Sparkless Commutation.* **G. Kapp.** (Elektrotechn. Ztschr. 20. pp. 32–35, 1899.)—From theoretical considerations regarding the energy stored up in an armature coil, and the peripheral width of the field due to the short-circuited coils, the author deduces the following two formulæ, which represent the necessary and sufficient conditions for sparkless running:—

$$B_a = C_0 \frac{\Delta}{n} \text{ and } 1 = C_1 \frac{\delta}{R} \cdot \frac{S}{1+n},$$

where B_a is the induction in air-gap, Δ = flow of current in armature conductors per unit length of circumference; n = number of commutator segments covered by a brush; δ = length of air-gap; R = radius of armature; S = number of segments in commutator. C_0 and C_1 denote two constants, whose values—as deduced from experiments carried out by the author and others—are as follows:—

$C_0 \geqq 12$ for smooth-core gramme armatures
$C_0 \geqq 24$ for toothed-core gramme armatures
$C_0 \geqq 9$ for smooth-core drums
$C_0 \geqq 15$ for toothed-core drums
$C_1 \leqq 0{\cdot}4$ for metal brushes
$C_1 \leqq 0{\cdot}8$ for carbon brushes

(See also Electrical Engineer, 23. pp. 198–200, 1899.)

A. H.

1084. *Theory of Commutation.* **E. Arnold and G. Mie.** (Elektrotechn. Ztschr. 20. pp. 97–101, 136–138, and 150–152, 1899.)—A very elaborate mathematical theory of the process of commutation. The main results arrived at by the authors are the following: A necessary condition for sparkless commutation is $\frac{R_1 T}{L} > 1$, where R_1 is the contact resistance of the brush, L the inductance of the coil in the position of short-circuit, and T the duration of the short-circuit. Commutation takes place best when $e_T = I(R_s + 2R_v\frac{\beta}{b} + 2R_1)$, where e_T is the reversing E.M.F. at the instant when the coil is open-circuited, I = normal current in each armature conductor; R_s = resistance of short-circuited coil; R_v = resistance of connectors between coil and commutator segments; β = width of segment; b = width of brush contact. When this condition is fulfilled, the rate of change of the short-circuit current at the instant of open-circuiting is zero. Solutions of the differential equation of the short-circuit current are obtained in the form of power-series and hypergeometric series, and curves of the short-circuit current are plotted from these for a number of cases. The energy-transformations during the time of short-circuit are next discussed. It is shown that if commutation proceeds properly, the inductance of a coil does not give rise to dissipation of energy; the stored energy ($\frac{1}{2}LI^2$) becomes mostly converted into mechanical energy during the time when the initial current in the short-circuited coil is diminishing to its zero value. The current in the short-circuited coil, in fact, causes it to act as a motor until zero value of the current is reached. This conclusion is contrary to the hitherto generally accepted view—due to Joubert—that during the time of short-circuit the whole of the stored energy ($\frac{1}{2}LI^2$) is dissipated. This latter view would only be correct in the special case where the coil is moving in a field of zero intensity during the time of short-circuit; in which case sparkless running becomes impossible, and the stored energy of the coil is entirely dissipated in causing sparking and heating. Approximate methods of calculating the inductance of armature coils for both smooth and toothed cores are developed, and some useful practical deductions are given towards the end of the paper. The maximum value of I (the current carried by a single conductor) in toothed armatures should not exceed 150 to 180 amperes. If C=total number of external armature conductors, s=number of commutator segments, then for toothed armatures—

$$s \geqq \cdot 04 C \sqrt{I}.$$

A. H.

1085. *Hunting of Paralleled Alternators.* **G. Kapp.** (Elektrotechn. Ztschr. 20. pp. 134–136, 1899.)—It sometimes happens that alternators, which may be paralleled without difficulty, and which for a time will run in parallel without giving any trouble, exhibit the phenomenon of "hunting." The ammeters of the machines show, by the gradually increasing amplitude of their swings, that heavy equalising currents pass between the machines. Under certain conditions these currents may increase so far as to give rise to pulsations in the P.D. across the 'bus bars, or even to blow the fuses. These phenomena are only exhibited by direct-driven steam alternators, and are absent in belt-driven machines or those driven by turbines. On the other hand, it may happen that an alternator, driven by a steam engine giving a very uniform torque, hunts more strongly than another whose engine gives a much less uniform torque. Hence the action cannot depend *solely* on the degree of uniformity in the torque. Further, the fact that hunting has frequently been observed to develop very gradually suggests a species of resonance. Resonance, however, implies oscillations. Imagine an observer bound to a fly-wheel which revolves with constant angular velocity, and which is placed in front of the engine fly-wheel. If the latter revolves with constant velocity equal to that of the first fly-wheel, it will appear stationary to the observer. If, on the other hand, its velocity fluctuates between certain limits, it will appear to oscillate to and fro. Similar oscillations will take place between two rotating vectors, one of which, corresponding to the 'bus bar P.D., revolves with constant velocity, while the other, corresponding to the E.M.F. of the machine considered, revolves with varying velocity (the projections of the vectors on a fixed straight line representing the instantaneous values of the E.M.F.s). Consider the instant when the machine vector V_m passes its normal position relatively to the 'bus bar vector V_b in the positive direction. At this instant, the power developed by the machine is the precise equivalent of the power impressed on it by the engine (there being no acceleration). But since the speed of the machine is at its maximum, the vector V_m gains on V_b until the average speed is reached; at this instant, however, the output of the machine is in excess of the power which it receives from the engine, on account of the forward position of the vector V_m. Hence V_m is retarded until it reaches its normal position, and the output of the alternator is once more the equivalent of the engine power. The speed of V_m is now at its minimum, and it falls behind V_b, the load on the alternator diminishing and its speed increasing until the normal speed is reached. At this instant the output is less than that corresponding to the power of the engine, and acceleration takes place until the vector V_m once more reaches its normal position, and is on the point of passing V_b. The changes here described constitute a complete oscillation of the alternator armature. If the torque exerted by the prime mover were perfectly uniform, oscillations of this description if started (as, *e.g.*, by quickly closing and opening a circuit) could not last long, as they would be rapidly damped out by mechanical, magnetic, and electrical dissipation of energy. If, however, the impulses exerted by the engine follow each other at intervals equal to the period of oscillation of the armature, and if these impulses are sufficiently strong to cover the losses which damp the oscillations, the latter will persist. If the impulses are somewhat stronger, resonance takes place, and the evil is aggravated. It is thus obvious that the most important factor which determines the hunting is the ratio of the period of engine impulse t_e to the period of oscillation of the alternator armature t_a. If the ratio t_a/t_e assumes or approximates to one of the values $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, 1, 3, 5, trouble may be expected. t_e is at once readily determined from the construction and speed of the engine; t_a is shown by the author to be approximately equal to

$$2\pi\sqrt{\frac{18{\cdot}4\,e\,i}{v\,d\,m}},$$

where e stands for P.D. between 'bus bars; i for the short-circuit current of the alternator armature corresponding to normal excitation; v for the peripheral velocity, in metres per second; d for the pitch of the pole-pieces, in metres; and m for the moment of inertia of rotating part of machine, divided by its radius (kg. and metre as units). In most cases, $t_a > t_e$. If t_a/t_e is found to have a dangerous value, the following expedients may be used to prevent hunting: (1) surrounding pole-pieces by heavy copper rings; (2) increasing or decreasing weight of fly-wheel; (3) inserting a choking-coil between the alternator and the 'bus bars; this last expedient is the cheapest, and has the same effect as increasing the moment of inertia of the rotating part. It is important to notice that under certain conditions a slight increase in the moment of inertia, so far from curing hunting, may aggravate it. A. H.

1086. *Compounding of Alternators.* **E. Danielson.** (Elektrotechn. Ztschr. 20. pp. 38–39, 1899.)—The article contains an illustrated description of a machine built on the plan recently patented by the author; this has already been noticed in a previous abstract (see 1898, Abstract No. 862), and the machine illustrated in the present article is constructed precisely as shown by the sketch there given. Some interesting results obtained with this machine are embodied in the accompanying curves, the lower curve in each case giving the characteristic corresponding to constant field excitation, and the upper one the characteristic with the compounding device in action. The curves in Fig. 1 refer to a non-inductive load, those in Fig. 2 to an inductive load of power-factor 0·8. A. H.

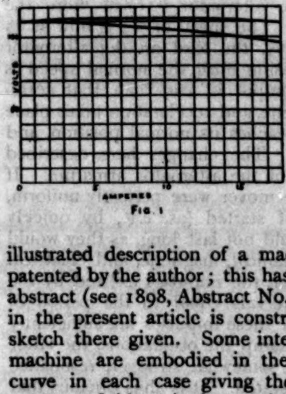


FIG. 1

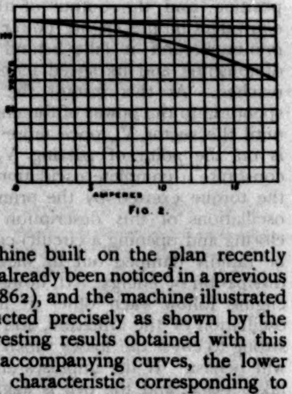


FIG. 2.

1087. *Alternating Current Motors.* **E. J. Berg.** (Amer. Electn. 11. pp. 17–19, 1899.)—This article deals chiefly with synchronous motors, and points out that such motors do not work well on high-frequency circuits or from direct-driven generators. For synchronous motor-working the generators should, if worked by steam power, be belt-driven. W. G. R.

1088. *Induction Motors.* **W. Baxter, Jr.** (Amer. Electn. 11. pp. 121–123, 1899.)—This is an attempt to explain in a popular manner the way in which energy is transferred from the primary to the secondary in induction motors with squirrel-cage rotors. The explanation is based upon the assumption of a magnetic field of constant strength rotating with uniform angular velocity, and depends upon the relative angular velocities of the field and the rotor windings. W. G. R.

1089. *Speed Variation of Alternate Current Motors.* **W. G. Rhodes.** (Elect. Rev. 44. p. 107, 1899.)—The author draws attention to the fact that alternating current motors would probably come into more general use if some combined voltage and frequency transformer were invented which would enable the speed of such motors to be varied. A. H.

1090. *Rectification of Alternate Currents.* **L. Kallir.** (Zeitschr. Elektrotechn. Wien. 16. pp. 602–604, and 613–615, 1898.)—The author discusses the various arrangements of circuits which may be adopted in connection with rectifiers having no moving parts—such, *e.g.*, as the electrolytic rectifier of Graetz and Pollak (see 1898, Abstract No. 207). In each case the equation to the current is fully worked out. The cases considered by the author are shown in the annexed sketches. The arrow affixed to each rectifier indicates the direction in which the current is allowed to flow. The arrangement shown in Fig. 1 is not to be recommended, as the current varies a great deal, reaching a zero value during each period. The connections

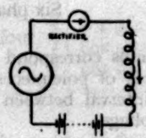


FIG. 1.

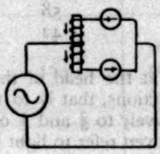


FIG. 2.

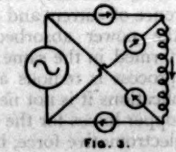


FIG. 3.

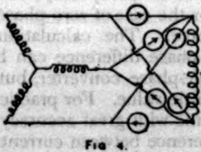


FIG. 4.

of Fig. 2 might with advantage be used for exciting the field-magnet of an alternator: the pulsations of the current are extremely slight. Fig. 3 shows an arrangement due to Graetz and Pollak, the characteristic feature of which is the utilisation of *both* half-waves of the alternate current; the pulsations in this case, with a reasonable amount of inductance in the circuit, are also slight. Lastly, Fig. 4 is an arrangement adapted to a three-phase circuit; the current may in this case be rendered remarkably constant. A. H.

1091. *Theory of Rotary Converters.* **G. Kapp.** (Électricien, 17. pp. 1–4, 21–24, 73–75 and 88–90, 1899, also Elek. Zeits.)—This is a mathematical discussion of the rotary converter. The following numerical results are given:—

E.M.F. of the alternating current for 100 volts continuous at motor brushes.		Nature of Current.
⅔	½	
75	82	One phase.
75	82	Two phases.
65	71	Three phases.
53	58	Four phases.
37	42	Six phases.

The ⅔ and ½ at the head of the columns correspond to the two usual constructions, that is to two sizes of pole-pieces which are equal respectively to ⅔ and ½ of the interval between two poles. The figures given refer to light load voltage.

The chief point considered is the losses as compared with other electrical machines. The following *résumé* of results is given: "Converters of three, four, and six phases have only been considered for the case of zero phase difference of current and electromotive force. The calculation of the power absorbed when there is a phase difference can be performed in the same way as for a single-phase converter, but the process is tedious and the result of little value. For practical applications it is not necessary to determine with great accuracy the copper losses for the case of phase difference between current and electromotive force, because the excitation is always so chosen that at full load this phase difference is zero. For small loads there may be phase difference, but the consequent increase in the copper loss is not of great importance, because the load, and therefore the actual loss, is but small. In the following table the power, in the case of a difference of phase, is determined by taking $\frac{\eta}{\cos\phi}$ as a factor of c, where η is the ratio of the maximum value of the alternating current to c, and c is half the value of the continuous current. For a monophase converter the value thus obtained is accurate. For converters of three, four, or six phases it is very approximate." In order to make the following table complete, there has been added the values obtained by Steinmetz for the limiting case, corresponding to a field which follows a sine law.

Power of a Rotary Converter, expressed in per cent. of the Power which it will furnish for Equal Copper Losses in the Armature as a Continuous Current Generator.

Type of Converter.	Power Factor.	Theoretical Limiting Case (Steimnetz).	Size of Pole-piece.	
			$\frac{2}{3}$	$\frac{1}{3}$
Single phase...	$\cos\phi=1$	85	88	95
	$\cos\phi=0{\cdot}9$		81	88
	$\cos\phi=0{\cdot}8$		73	80
	$\cos\phi=0{\cdot}7$		63	70
Three phases	$\cos\phi=1$	134	138	144
	$\cos\phi=0{\cdot}9$		128	137
	$\cos\phi=0{\cdot}8$		117	126
Two or four phases	$\cos\phi=1$	164	167	170
	$\cos\phi=0{\cdot}9$		160	167
	$\cos\phi=0{\cdot}8$		144	153
Six phases......	$\cos\phi=1$	196	198	199
	$\cos\phi=0{\cdot}9$		192	196
	$\cos\phi=0{\cdot}8$		177	188

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1092. *Electrical Equipment of Refrigerating Plant.* (Amer. Electn. 40. pp. 1–5, 1899.)—The lighting, ventilating, elevating power and partial pumping service for the Manhattan Refrigerating Co.'s New York storage and distributing plant is entirely electrical. Within the building, the refrigerating medium is brine circulated by steam pumps, but for the central station service to the adjacent market stalls liquid ammonia is used. The ammonia pumps are steam-driven, but the brine and water pumps are worked in pairs by 20 H.P. belted motors at 250 volts, which have to operate in the wet. Switches and contacts are silver-plated, to prevent chemical action with the ammonia or salt-laden atmosphere. Walls and ceilings being frequently snow-covered, special precautions had to be taken with conductors, which are twin-rubber and lead-covered, laid in steel pipe with outlet boxes filled solid with paraffin. Lampholders are of the porcelain waterproof type, hung by twisted cable from the outlet boxes. To get over difficulty with shocks from damp switches, a novel form of enclosed switch is used, consisting simply of a glass tube stoppered at both ends and containing a globule of mercury. When tilted in one direction the mercury joins the iron terminals, which pass through one of the stoppers. Forty 12-inch motor-fans are used for maintaining an even temperature throughout the storage rooms. A specially designed hanging waterproof bell has to be used with the telephones on account of the prevalent moisture.

E. H. C.-H.

1093. *City of London Electric Lighting Station.* (Elect. Rev. 44. pp. 337–340, 382–383, and 421–425, 1899.)—An account is given of this well-known station, which now contains plant to the extent of 11,660 kw., the two largest units (by Ferranti) being 1,500 kw. each.

W. R. C.

1094. *Power Station at Pittsburg.* **G. F. Greenwood.** (Elect. World, 33 pp. 203–205, 1899.)—The consolidated lines were found to require a station capacity of 6,000 kw., which was divided among six machines. Slow-speed horizontal engines were chosen as occupying less floor space than vertical engines. Their 20-feet fly-wheels weigh 100,000 lb. Coal is handled by conveyors which can deal with 40 tons per hour, and take 15 H.P. to operate. Each battery of water-tube boilers has a separate iron stack, 147 feet high by 5 feet 6 in. diameter. This is more economical in money and space than a single large stack. The switchboard is so arranged that any dynamo may be run alone or in parallel with others, with either its positive terminal to one 'bus bar, and its negative to ground, or with positive to ground and negative to another 'bus bar, while any feeder of the system may be connected to either 'bus bar. This corresponds to a 1,100 volt-system, and gives a smaller drop and greater freedom from electrolysis, due to the fact that large current does not return to the station through the ground, but distributes itself over a large area of the city, thus decreasing the necessary investment in ground wire. The disadvantages are complication of the switchboard and the necessity of having special 1,100 volt circuit-breakers on the lines, since failure of one of these breakers would produce a short circuit. A regulating storage battery is used. A novel feature is the interlocking pneumatic switchboard, somewhat similar to that at the Cataract Company's Station at Niagara Falls. E. H. C.-H.

1095. *Pittsburg Power Station and Shops.* (Street Rly. Journ. 15. pp. 127–140, 1899.)—This article contains a detailed and fully illustrated description of the power station, repair shops, and equipment of the Consolidated Traction Company's lines in Pittsburg. (See preceding Abstract.)

The repair shops are fully equipped with tools, travelling crane, traversers, dismantling pits, &c., all operated electrically. A pair of wheels, or both axles with their motors, can be removed from the truck, and a new set substituted in twenty minutes by five men. Wheels are ground by a Murphy wheel grinder without removing them from the car. Compressed air at 60 lb. is used for blowing out motors, cleaning car cushions, &c. Each of the 120 new cars carries two 50 H.P. motors, with electric brakes on motor cars and trailers. E. H. C.-H.

1096. *Blackburn Electric Tramways.* (Elect. Engin. 23. pp. 334–340, 1899.)—The Siemens dynamos are arranged with two commutators normally connected in series for traction work, but put in parallel for connection on to the lighting 'bus bars in emergencies. Instead of the usual guard wires over the trolley line, the Telephone and Post Office authorities have sanctioned wire cradles underneath their own wires. English-made motors and controllers are used and a special form of trolley head and support. E. H. C.-H.

1097. *Detroit Interurban Electric Railways.* (Street Rly. Journ. 15. pp. 1–8, 1899.)—There are six lines going out from Detroit, 20 to 40 miles each. Cars run at the side of the highway at 30 to 40 miles per hour with 30 minutes' headway. The lines are divided into 5-cent zones, the average fare being 1 cent per mile. The system is 500–650 volts, with boosters for long lines. One of the latest lines uses 500 H.P. units, 250 H.P.

Babcock boilers, with mechanical stokers and draft. Another uses a special arrangement of forced draught producing a 5-oz. pressure at the expense of 2 per cent. of the output from the boilers. Rigid brackets in the overhead work have been discarded on account of wire breaking at the hangers. Long, heavy cars are used, some over 50 feet. Each has a baggage and smoking compartment, and some carry state rooms, with lavatory, water cooler, &c. One line has applied the Westinghouse air-brake with automatically controlled motor and compressor. Two 75 H.P. motors are preferred to four 50 H.P. motors.

E. H. C.-H.

1098. *Argentine Electric Tramways.* (Street Rly. Journ. 15. pp. 69–74, 1899.)—Horses and fodder are cheap and coal is expensive (6·50 dollars per ton), yet electric traction pays and is being extended. The power station of La Capital Tramways Company contains 450 H.P. Ball-Walker units, Stirling boilers, and Sturtevant induced draught apparatus. The heavy ox-carts, which weigh 15 tons and have 10-feet wheels, snap off tie-rods on country roads; braced tie-plates are now being used.

E. H. C.-H.

1099. *Cross-Country Line at Lewiston, U.S.A.* (Elect. World, 33. pp. 255–258, 1899.)—The main line of the Lewiston, Brunswick, and Bath street railway extends 30 miles from Lewiston to Bath, with urban branches at both ends, making a total of about 60 miles. Power for the whole line is obtained from falls near Brunswick, where 1,000 H.P. has been leased for 10,000 dollars per annum. Four Victor turbines, under 17 feet head, with Lombard governors, are all mounted on the same shaft, which drives the main countershaft by rope. Three 250 kw., double-current, Westinghouse generators are driven by clutch-pulleys on the countershaft. The whole 250 kw. may be delivered through the commutator at one end of the armature, or taken as alternating current from collector rings at the other end, or in any proportion from both ends simultaneously. Speed is 600 revolutions per minute, frequency 60, direct current voltage 550, and three-phase voltage from the same windings 330. The machines are practically rotary converters. with an added pulley and outer bearing. They are compound-wound. The direct current panels of the switchboard are of the usual pattern; the three-phase generator-panels carry an ammeter on each phase, a triple-pole switch, and a special field resistance with fine adjustment. The three-phase current is transformed in a separate building to 10,000 volts by Westinghouse, oil insulated, self-cooling, 125 kw. transformers, with tappings so arranged that different numbers of turns can be cut off from one end of the low tension winding, thereby enabling the ratio of transformation to be changed by 6¼, 12½, or 18¾ per cent. The 10,000 volt switches consist of plugs on the end of 3-feet wooden poles with flexible connections. The plugs enter brass sockets with spring contacts on marble slabs. The fuses consist of a foot of aluminium wire in soft rubber tube, supported on triple-petticoated porcelain insulators. Of the two high-tension lines one runs 10 miles and the other 20, to rotary sub-stations. The converters are 10-pole machines at 720 r.p.m., with practically the same windings as the generators. They carry at one end small three-phase induction motors for starting the rotary, the motor being wound to give a high torque at standstill, and having a smaller number of poles than the rotary, so that it will bring the speed slightly above sychronism, giving a good opportunity for closing the main switch while passing the critical point.

E. H. C.-H.

1100. *Stansstad-Engelberg Polyphase Railway.* (Electrician, 42. pp. 460–465, 1899.)—The metre-gauge line is laid with 52-lb. Vignoles rails with steel sleepers. In parts a ladder rack is used, the first and last section of which are supported on strong conical springs, and have revolving teeth to prevent the pinions mounting. The bonded rails form the third wire of the three-phase system. Radial-flow high pressure Pelton wheels are direct-coupled to three-phase generators with revolving armatures. With a head of 1,250 feet, the output of each set is 180 H.P. The shunt-wound exciters are driven by 12 H.P. turbines at 750 volts without governors. Three 30 kw. transformers behind the switchboard raise the voltage to 5,200. An automatic switch is arranged to interrupt the exciter current in case of an earth on the high-tension line. The two trolley wires of 7·5 mm. diameter are suspended 3 feet apart on span wires. The high-tension line is carried on the outer side of the poles which also carry the low-tension feeder lines, fed from three single-phase transformers at a midway station. The State telephone line runs parallel to the railway, but buzzing is heard only on wet days. At one point the line crosses the main road by a drawbridge, and at another it crosses a direct current tram line.

The 46-feet bogie motor cars weigh 14 tons empty, and carry 46 passengers, with luggage and mails. The front bogie carries two 35 H.P. 750-volt induction motors, running at 480 revolutions per minute and driving through single reduction gearing. Current is collected by two double sliding contacts. The stator current is controlled on the driver's platform by a two-way switch, under which are placed four enclosed high-tension fuses for the stator circuit of both motors. The third end of the stator winding is connected to the bogie frame. The rotor current is collected by double carbon brushes from the slip-rings, from whence it passes to the rotor resistance placed on the roof. The resistance is worked by a lever placed above the controller on the driver's platform. The cars are heated and lighted electrically, current for the lighting being supplied at 100 volts by a small transformer placed in the luggage compartment. The heaters are placed, seven in series, under the seats, and are connected directly to the 750-volt line. Each car is fitted with two brakes: the one is a powerful hand-brake applied to all the eight wheels of the car, the second is a pinion brake acting on the pinion placed on the rear bogie, and is only used when the car is running over the rack. The maximum speed for which the cars are designed is 12½ miles an hour; the speed is only varied by means of a rheostat in the rotor circuit.

The 12-ton locomotives carry two induction motors giving 75 H.P. at 650 revolutions, and each weighing two tons. Both motors are geared to a common shaft, which is again geared to the driving pinion running in the rack. The gearing is so dimensioned as to give the locomotive a speed of 3·1 miles an hour on the rack. By means of a friction coupling and connecting-rod the motors can be connected to the driving wheel, making it possible to run the locomotive at a speed of 7½ miles an hour on the adhesion line. The rotors are controlled by a reversing switch in the stator circuit and a resistance in the rotor circuit. Three independent brakes are in use. The first is a hand-brake acting on the driving wheels; the second is a hand-brake, acting by means of four gun-metal shoes pressed on two wheels keyed to the driving pinion; the third is an automatic brake, which acts as soon as the speed of the locomotive exceeds 4½ miles an hour on the rack. The latter consists in the main of a centrifugal governor keyed to the motor-shaft; this releases a weight, which in its fall opens the switch in the stator circuit and couples the brake spindle to the motor-shaft, so tightening the brake shoes on the brake pinion and on a pinion placed loose on the rear axle of the truck. By means of this brake it is possible to stop a train weighing 28½ tons, and going at a speed of three miles an hour, on the 25 per cent. gradient in a distance of 20 feet. The motor cars will draw a trailer up a 2·3 per cent. gradient at 12 miles per hour; while, on the rack, the locomotives push the car up at 3 miles per hour. In descending, the speed of the motors tends to rise above synchronism, and the current given back to the line then makes the turbines race, unless a car is going up or a water resistance is put into the generator circuit. Extensions to 600 H.P. capacity are contemplated. (See also 1899, Abstract No. 936.) E. H. C.-H.

1101. *Graphical Solution of Traction Problems.* **J. Neidt.** (Elektrotechn. Ztschr. 20. pp. 39–43 and 57–59, 1899.)—The first part of the paper deals with the problem of determining the velocity of a tram-car at every instant when the resistance in the motor circuits at starting is varied in such a manner as to maintain a constant current through them which will produce the greatest possible tractive effort—the wheels being just on the point of skidding. The acceleration will then be constant, and the velocity will increase in simple proportion to the time; this will go on until the whole of the starting resistance has been cut out, the motors being in parallel. Any further increase of speed will result in a reduction of the current, and a consequent decrease in the acceleration. The law connecting speed and torque of motor is given by its mechanical characteristic; for the problem in hand, it is convenient to plot a curve connecting total pull with speed of car. Instead of supposing that the pull decreases steadily with the speed, it is assumed that it decreases by sudden jumps or steps; during each step (*i.e.*, between two given limits of speed) the acceleration is taken to be constant. This assumption enables us to obtain (approximately) a number of points on the time-speed curve, and so to construct the entire curve. The frictional resistance due to the rails and air resistance must, of course, be subtracted from the total pull to get the accelerating pull. With frequent stoppages, it is essential to use motors giving rapid acceleration. Examples are given of the advantages of rapid acceleration. In the second part of the paper the author deals with the graphical determination of the starting resistances, and the resistances to be used in the motor circuits when their generator action is used for braking purposes. A. H.

1102. *Guest Closed Conduit System.* (Elect. Engin. N.Y. 27. pp. 205–206, 1899.)—All the apparatus is contained in 4-inch by 3-inch channel iron, laid as a continuous central conduit. The cover to this conduit is bolted on in sections, insulated from the conduit and from each other, and carries all the working parts. Iron induction plugs are secured at frequent intervals in the cover, from which they are magnetically insulated. The only electromagnet is carried on the car, is energised by the motor current or by cells, and operates, by induction through the plugs, on a pendulous armature which connects the section of cover-plate on to the feeder. A few series-turns round the plugs ensure firm contact when once the cover-plate is alive. When the car and its magnet move on, the pendulous armature drops and breaks contact between feeder and cover-plate. E. H. C.-H.

1103. *Motor-Cars in New York.* **G. H. Condict.** (Elect. World, 33. pp. 261–262, 1899.)—In the recent blizzard, the motor-car proved its usefulness by operating when all horse traffic was stopped. The greatest difficulty at present is with tyres. All kinds have been tried on the New York electric cabs, but a satisfactory one has not yet been obtained. Rear pneumatics and front solids are advantageous. E. H. C.-H.

1104. *Electric Lighting of Country Houses.* **B. M. Drake.** (Elect. Engin. 23. pp. 141–143, 1899. Paper read before the Royal Institute of British Architects.)—A brief comparison of the various kinds of generating plant (steam, gas, and oil engines, &c.) is given, and practical hints as to plant, cost, &c. The artistic illumination of rooms is also considered. W. R. C.

1105. *Thomson-Houston Enclosed Arc Lamp.* **T. Pausert.** (Écl. Électr. 18. pp. 91–99, 1899.)—In this article, descriptions, accompanied by photographs and diagrams of connections, are given of continuous current lamps with simple winding, with differential winding, and with the regulating coil arranged concentrically around the upper carbon-holder; and of an alternate current lamp. Short descriptions are also given of lamps arranged for special purposes. Various forms of nipper or tong clutch are shown, actuated by linkwork from the core or cores of the regulating solenoid or solenoids. The alternate current lamp has a reaction coil provided with a number of terminals, so as to enable the lamp to be worked at frequencies of 42, 50, 83, or 100 periods per second, and at pressures ranging from 98 to 120 volts. Lamps for working in series on high tension alternate current circuits are also described, in which there are no reaction coils, the lamps being fed through a special transformer, in which the primary coil is fixed, and the secondary coil can approach or recede therefrom. This motion is automatic, so as to keep the current in the secondary circuit absolutely constant. For this purpose the coils are enclosed in a casing filled with oil, and the secondary is supported by counterweights so that at full load the secondary coil is close against the primary, and the electromotive force in the secondary is a maximum, at other loads the secondary coil taking up a position corresponding to the resistance in the secondary circuit. These transformers are made for 25, 50, 75, or 100 lamps.

The inner globes of the lamps cost 1·20 fr., and require to be replaced at the end of 400 hours' lighting, *i.e.*, 1·20 fr. per month for two lamps; the consumption of carbon 25 cms. per 100 hours, *i.e.*, 0·60 fr. per month for two lamps; for lighting 7 hours per day, the cost of attendance for two lamps is 1 fr. per month. Total for maintenance is thus 2·80 fr. per month. C. K. F.

TELEGRAPHY AND TELEPHONY.

1106. *Siphon-recorder Signals.* **J. Rymer-Jones.** (Elect. Rev. 44. pp. 36–38, 77–79, 191–194, and 484–486, 1899.)—The shape of signals received and recorded by a siphon-recorder for a given cable depends upon a great many conditions and adjustments of instruments both at the sending and receiving end of the cable. The author gives about two hundred examples of actual "recorder slip" obtained by himself and E. Raymond-Barker on a particular siphon-recorder under different conditions of working through a long artificial cable. The various factors considered are: (1) Capacity of "signalling" condensers at the "sending" end; (2) Capacity of "signalling" condensers at the "receiving" end; (3) Speed of transmission; (4) Battery power; (5) Shunts of recorder coil; (6) High-resistance shunts connected so as partially to short-circuit the "signalling" condensers; (7) The effect of using condensers of low insulation; (8) The effect of artificial "leaks"; (9) Length of cable. An automatic transmitter was used, and the speed was varied between 16 and 25 words per minute. It is impossible to describe the results without referring to the 216 recorder "slips," but a few points may be noted. For short cables, a signalling-condenser at one end only is a better arrangement than signalling-condensers at both ends. The falling-off of signals towards the zero-line can be modified by adjustment of the bifilar suspension, or by shunting the signalling condensers at either end. Increasing the capacity of the signalling condensers at both ends of a long cable increases the amplitude; but above a certain capacity the "definition" is not improved. Signals may generally be improved by a proper proportioning of the capacity of the "sending" to that of the "receiving" condensers. Altering the speed may change the shape as well as the size of signals. When signalling-condensers are used at only *one* end of the cable, the effect of shunting them with a high resistance is to make the signals rise as a whole from the zero-line; the effect of condenser-shunts, when signalling-condensers are used at *both* ends, is to make the signals fall away from the zero-line. The high insulation of signalling-condensers is of importance only when the cable is subject to strong and varying earth-currents; in other cases, condensers of low resistance may tend to improve the shape of signals. The effect of low insulation in the cable itself is to cause the signals to fall towards the zero-line; this fall may be partially compensated by the use of signalling-condensers of low resistance. The effect on the amplitude of signals of a "leak" in the cable is a maximum when the leak is at the middle of the cable.

[All the results were obtained using the artificial cable, neglecting self-induction; to this extent they may differ from the results of ordinary cable-working.] R. A.

1107. *Relay-transmitters.* **E. Lönnqvist.** (Journ. Télégraph, 23. pp. 6–10, and 25–29, 1899.)—A description with illustrations is given of the arrangement of telegraphic apparatus adopted by the Director-General of Swedish Telegraphs. It includes an account of the relay-transmitter system introduced recently into Sweden. R. A.

1108. *Lodge and Muirhead's Syntonic Coherer Telegraph.* **J. Blondin.** (Écl. Électr. 18. pp. 81–86, 1899.)—Other things being equal, a resonating receiver will respond to weaker waves, and therefore at greater distances than a non-syntonic one. The Righi spark-gap prevents the coil from seriously affecting the periodicity at the sending end and at the receiving end, as the receiver is normally a non-conductor. The author thinks Lodge's precautions in connecting the resonator to it are of little use. Turpain's connections of '95 are said to be almost identical with Lodge's. Tietz's experiments confirm the value of a condenser in the earth connection. Turpain studied in '95, and published some months before Lodge, a system of Hertz waves transmission on telegraph networks. M. O'G.

1109. *Wireless Telegraphy.* **W. Bissing.** (Elect. World, 33. pp. 55–57, 83–86, 110–111, 1899.)—In this series of illustrated articles a precise account is given of the history of electrical methods of telegraphing without line wires, from the experiments of Lindsay in 1854 to the recent work of Marconi and Lodge. It contains references to various patents and other sources of information, and is an extension of S. P. Thompson's review of the subject in April, 1898, in the Journal of the Society of Arts. R. A.

1110. *Electrostatic and Magnetic Causes of Cross Talk.* **K. B. Miller.** (Amer. Electn. 11. pp. 28–29, 1899.)—The author shows, with diagrams, the effect of crossing the lines of metallic circuits. M. O'G.